CHEMICAL

NORWOOD.

PROBLEMS.

EXPERIMENTAL EXERCISES

AND

PROBLEMS

IN

ELEMENTARY CHEMISTRY:

TOGETHER WITH VARIOUS CHEMICAL TABLES, AND TABLES
FOR THE CONVERSION OF COMMON WEIGHTS
AND MEASURES INTO THOSE OF

THE METRICAL SYSTEM.

FOR THE USE OF BEGINNERS.

COMPILED BY

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COLUMBIA, MO.:

PRINTED FOR THE AUTHOR'S CLASS.

NEW YORK: RICHARDSON & CO., 14 BOND STREET.

1868.

STEREOTYPED AT THE FRANKLIN TYPE FOUNDRY, CINCINNATI.

NOTE.

THE following pages were compiled expressly for the use of my own classes, and without any view to general publication. The Principals of two of our neighboring Colleges, however, on being made acquainted with the proposed plan of instruction, desiring copies for the use of their pupils, I have had an additional number printed for them; and, if the method should commend itself to teachers in other institutions, the edition could be extended to meet their wishes.

The work is a mere compilation from text-books recently published in England, by some of the most eminent and successful teachers of Elementary Chemistry in the Colleges and Universities of that country. None of the works from which the materials were extracted have, as yet, been republished in this country. They are Prof. FRANKLAND'S "Lecture Notes for Students," Prof. GALLOWAY'S "First Step in Chemistry," and "Second Step in Chemistry," Prof. WILLIAMSON'S "Chemistry for Students," Prof. ROSCOE'S "Lessons in Elementary Chemistry," Prof. WILSON'S "Inorganic Chemistry," and Prof. HOFMANN'S "Introduction to Modern Chemistry." Most of the Problems have been extracted from Prof. GALLOWAY'S "First Step," and if that work could have been obtained for the use of my classes, there would have been less necessity for this compilation; but repeated efforts to obtain copies, made during the last year and a half, only resulted in the information that it was "out of print."*

The experience of many years, as a teacher of Chemistry, has convinced me that, even in our best Colleges, with all the aids of apparatus, and in the hands of thoroughly qualified teachers and manipulators, a large majority of pupils fail to gain such a knowledge of the *principles* of the science, as ought to repay them for the time faithfully spent in the attempt. This failure is due, I think, not so much to want of qualification in the teacher, or of industry in the student, as to the generally defective *plan* of teaching. If we put out of view, entirely, the eminently practical nature of this science, considered in its technical relations, and consider it only as part of the general means of mental discipline, we shall find

* Since the following pages were in type, I have received a letter (dated January, 1868) from the London publishers of "The First Step in Chemistry," stating that a new edition has just been published.

the failure quite as great in the last as in the first case. The student has *no work to do for himself.* All he is required to do, or, in fact, can do, under the methods pursued in many of our Academical Institutions, is to retain in his memory as much as he can of the lecture, memorize the appointed lesson in his class-book, and recite what he can remember of them to his teacher when called upon.

Chemistry is a science of numbers, as well as of experiment; and if the arrangements in our Colleges were such (and they ought to be) as to admit of every student using the apparatus and experimenting for himself, still he would fail to master the principles of the science without the aid of mathematics and the blackboard. Exercising the memory only is not the best method, either for making chemists or for disciplining the mind of the pupil. Prof. GALLOWAY, of Dublin, who was among the first to propose a better method of teaching Chemistry, as a branch of general education, says: "Few persons could learn arithmetic by simply attending *lectures*, or by *reading;* these important means of deriving instruction require to be followed up by the practice of exercises on the part of the student. Fewer still could become proficient in this branch of useful knowledge, if not only should the use of exercises be denied, but the various operations of addition, subtraction, multiplication, and division be presented indiscriminately to the mind, and not, as is the invariable practice, treated separately. Strange, however, as it may appear, the method of teaching the language of Chemistry, which is certainly not less difficult to acquire, has been hitherto characterized by the defects just enumerated. Yet, without a knowledge of this important part of Chemistry, no real progress can be made in the science." He says, further, that by the new method he found the elements of Chemistry "capable of being taught even to boys of ten or twelve with as much success as the ordinary subjects of education."

The "PROBLEMS" may be successfully solved by the aid of the principles taught in most of the Text-books used in American Colleges. Among these may be mentioned the elementary works of Silliman, Johnston, Youmans, Draper, Fownes, Eliot and Storer, Graham, Turner, Taylor and Brande, Miller, Abel and Bloxam, Kane, Regnault, Stöckhardt, Wells, etc., etc.

The work is intended for the use of beginners only, and to aid them, in connection with the Class-book, and the lectures and experimental demonstrations of the teacher, to master the first principles of Chemistry, by a method equivalent to that by which the principles of arithmetic and algebra are acquired, as prerequisites to the study of the higher branches of mathematics.

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EXPERIMENTAL EXERCISES

AND

PROBLEMS.

1.—Fill a small balloon of gold-beater's skin, or collodion, with hydrogen gas. The balloon will rise to the ceiling of the room.—Explain the phenomenon; and state the weight of hydrogen as compared with that of other bodies.

2.—Prepare some carbonic acid gas, by placing in a bottle, furnished with a delivery tube, some fragments of marble, or chalk, and pouring upon them, by means of a funnel tube, equal parts of hydrochloric acid and water. The delivery tube in this experiment should dip into a dry glass vessel, and reach to the bottom. As soon as the vessel is filled with the gas, which is ascertained by a candle being extinguished when introduced just below the edge of the vessel, pour the gas, as you would a liquid, into another vessel of the same size and shape. Prove that the gas has been really transferred from the one vessel to the other, by introducing a lighted candle, first into the vessel originally containing it (in which the candle ought now to burn), and then into the one into which it was poured, and in which the candle ought now to be extinguished.—What does this experiment teach?

3.—Fill a wide and deep glass jar half full of carbonic acid gas, the upper half being filled with atmospheric air. Fill a collodion balloon with a mixture of hydrogen and air in such exact proportions that the balloon will just sink in air. When so prepared, let the balloon sink into the jar; and as soon as it reaches the uppermost layer of carbonic acid it will rebound as if it had touched a solid body. Finally, it will float quietly upon the carbonic acid.—What does this experiment illustrate?

4.—Place a few fragments of sulphur in a Florence flask, and then heat the flask by means of a gas or spirit lamp. The sulphur will become liquid; and, if the heat be long continued, it will finally be converted into vapor. If the vapor be received into another flask, which is kept cool, it will be reconverted into the solid state.—What is proved by this experiment?

5.—Perform a similar experiment with small pieces of iodine, introduced into a large flask; and then heat the flask by means of a spirit lamp. Notice the color of the vapor.

6.—Fill very nearly a small glass retort with water, and then introduce a little sulphuric ether. The latter liquid will swim above the water in the upper part of the retort. Invert the beak of the retort in a vessel

of water. Then apply a gentle heat to that part of the retort containing the ether. The heat will convert the liquid ether into vapor, and more or less of the water will be expelled from the retort. On removing the heat and allowing the glass to cool, the water will flow back into the retort.—Explain the phenomena.

7.—Half fill a retort with water, place it upon a retort-stand, and insert the beak in a flask. Keep the flask cool by means of a wet cloth or ice. Heat that part of the retort containing the water by means of a spirit lamp.—What will take place? and what is the explanation of the phenomena?

EXERCISES ON THE COMBINATION OF TWO ELEMENTS.

8.—Place a piece of phosphorus, about half the size of a pea, in the deflagrating spoon (having previously dried the P. by pressing it gently between folds of blotting paper), and hold the spoon in the flame of a spirit lamp until the phosphorus takes fire. Then introduce it into a jar filled with oxygen gas.—What will take place?

9.—Dry a piece of phosphorus similar in size, and in the same way, as directed in Expt. 8. Cut it into small fragments, and introduce them unignited, by means of the spoon, into a glass jar filled with chlorine.—What will take place?

10.—Place a few fragments of phosphorus (dried) upon a plate, and throw upon them a small quantity of iodine.—Describe the phenomena.

11.—Place a piece of roll sulphur, about the size of a pea, in the bowl of the spoon, hold the bowl in the flame of a lamp or candle until the sulphur takes fire, and then introduce it into a wide-mouthed bottle or jar filled with oxygen gas.—What will take place?

12.—Introduce, by means of the spoon, a piece of red-hot charcoal into a jar filled with oxygen gas.—Describe the phenomena.

13.—Coil a thin iron or steel wire around a stick, so as to bring it into a cork-screw shape, and then draw it off. Tip one end of the wire with sulphur, by immersing it in melted brimstone, the other end being fixed into a cork which fits the mouth of the gas jar. The sulphur having been ignited, the spiral wire must be immediately inserted into a jar filled with oxygen gas, and the cork closely pressed into the mouth of the jar.—Describe the phenomena.

14.—Put a little powdered antimony into a small muslin bag, and shake the bag over the open mouth of a jar filled with chlorine, in such a manner that the small particles of the metal coming through the muslin may fall into the jar.—What will take place?

The Expt. may be varied by substituting powdered metallic arsenic for the antimony. In both cases the experimenter must be very careful not to inhale any of the chlorine gas or the vapors formed.

THE CONDITIONS NECESSARY FOR COMBINATION.

15.—Introduce a piece of dry phosphorus into a jar of oxygen; notice the result, and then repeat Expt. 8.—Explain the cause of the difference in the phenomena.

16.—Dissolve some nitrate of lead in water, and also some iodide of potassium in water. Add a part of the solution of iodide of potassium to the lead solution.—Explain the reactions.

17.—Dissolve some corrosive sublimate (chloride of mercury) in water. Add to this solution the remainder of the iodine solution.—Explain the reactions.

18 —Dissolve some sulphate of iron in water, and add to the solution some sulphide of ammonium.—Explain the results.

19.—Dissolve some sulphate of zinc in water, and add to the solution some sulphide of ammonium.—Explain the reactions.

CHANGE OF FORM.

20.—Place some fragments of marble or chalk in a deep glass vessel, add water enough to cover them to the depth of half an inch or an inch, and then add some hydrochloric acid. Effervescence will ensue on the addition of the acid.—Explain the phenomenon.

21.—Take two precipitating vessels of equal size (tumblers will do), moisten the sides of one with a few drops of aqua ammonia, and the sides of the other with a few drops of hydrochloric acid. (Ammonia and hydrochloric acid are gaseous bodies, and they escape from their aqueous solutions when exposed to the air. The atmosphere of the jar becomes, therefore, filled with these gases.) Then bring the mouths or openings of the two vessels together.—What will take place? and what will be formed?

UNION OF ELEMENTS.

22.—Introduce into a jar filled with nitrogen gas a small piece of ignited phosphorus, by means of the deflagrating spoon.—What will take place? Explain the phenomenon.

23 —Introduce into a jar filled with nitrogen gas a fragment of ignited sulphur, by means of the deflagrating spoon.—What will be the result? and why?

24.—Introduce a piece of dry phosphorus into a jar of oxygen by means of the spoon.—What will take place?

Then introduce a piece of ignited phosphorus into the same jar.—What will be the result? and why?

25.—Introduce a piece of unignited phosphorus into a jar filled with chlorine gas, (as directed in Expt. 9).—What do these experiments teach in regard to combination?

26.—Place in a beaker, or other convenient glass vessel, a piece of phosphorus, and half fill the vessel with water. Fill a bladder, or India rubber bag, which is fitted with a stop-cock and bent delivery tube, with oxygen, and direct a stream of the gas upon the phosphorus. When the two elements come in contact, no reaction will take place. Then increase the temperature of the water 10° F., and again direct a stream of oxygen upon the phosphorus. Continue to increase the temperature of the water 10° F., after each occasion that the oxygen has been directed upon the phosphorus, until the phosphorus bursts into flame.—At about what temperature will this take place? and what principle does this experiment illustrate?

27.—Form a small metallic spiral by twisting a piece of copper wire around a pencil. Then place it cold over the flame of a wax taper.—What will take place? Then heat the spiral to redness, in the flame of a spirit-lamp, and place it over the flame of the taper.—What will be the result? and why?

28.—Lay a piece of camphor on some wire gauze, and kindle it. The camphor will burn on the surface with a smoky flame, and a portion of the melted mass will pass through the gauze to the under side, but will not burn.—Why not?

29.—Place a piece of wire gauze over a jet from which an inflammable gas (such as coal gas) is issuing; apply a light to the upper surface of the gauze, and the gas will instantly take fire. Raise the gauze an inch or two above the jet from which the gas is issuing; and, while the gas above the wire will continue to burn, that below will remain unignited.—Explain the experiment.

30.—What elements do the following symbols stand for:—

Fe—Au—Br—Mn—Cd?

31.—Give the symbols for the following elements:—

Magnesium—Lead—Chlorine — Copper — Platinum — Potassium — Sodium.

32.—How are the Metals distinguished from the Metalloids?

33.—Name the elements which are gaseous, and those which are fluid, at the common temperature.

34.—Of what elements are the following compounds composed:—

H O—Pb S—Na Cl—Ca F—Fe O—K Br—Ca O—Zn I—Co O?

35.—What is weight?

36.—In what respect does the attraction of Gravitation differ from the attraction of Cohesion and Chemical Attraction?

37.—What is the difference between a mere mixture of substances and a chemical compound?

38.—What is the burning of phosphorus, of carbon, of sulphur, of hydrogen, in the air, due to?

39.—Repeat Expt. No. 13; and describe the reactions which take place.

40.—Make the same Expt. (No. 39), with the exception, that instead of plunging the wire into oxygen gas after the sulphur is ignited, allow it to remain in the air.—Explain the result.

RESULTS OF COMBUSTION.

41.—Introduce a piece of ignited phosphorus into a jar of oxygen, as in Expt. 8.—What will be formed.

42.—Introduce a piece of unignited phosphorus into a jar of chlorine, in the way described in Expt. 9.—What will be formed?

43.—Add some phosphorus and iodine together, in the way described in Expt. 10.—What will be formed?

44.—Introduce a piece of ignited phosphorus into a jar of nitrogen, as described in Expt. 22.—What will be formed?

45.—Introduce some burning sulphur into a jar of oxygen, as described in Expt. 11.—What will be formed?

46.—Take a fragment of sulphur and melt it in the cup of the spoon; as soon as it is liquid, and before it takes fire, introduce it into a bottle filled with chlorine gas. What will be the result? and what will be formed?

47.—Introduce some burning sulphur into a jar of nitrogen, in the way described in Expt. 23.—What will be the result?

48.—Burn some iron wire in a jar of oxygen, in the way directed in Expt. 13.—What will be formed?

49.—Make a small ball of turnings of zinc, and inclose in it a small fragment of phosphorus. Place the ball in the cup of the spoon, and set fire to the phosphorus by means of a lamp. Then introduce the spoon as quickly as possible into a jar of oxygen.—Describe the phenomena, and state the result.

50.—Place a few small fragments of antimony in the cup of the spoon, and then heat them in the flame of a lamp until they take fire. Introduce the burning metal immediately into a jar of oxygen.—What will be formed?

51.—Introduce some powdered antimony into a jar of chlorine, in the way described in Expt. 14.—What will be formed?

52.—Introduce some ignited charcoal into a jar of oxygen, in the way described in Expt. 12.—What will be formed?

53.—Generate some hydrogen gas in a common round bottle, by the action of dilute sulphuric acid on granulated zinc. Fit a narrow glass tube into a perforated cork, the latter fitting air-tight into the neck of the bottle. The tube should be made of hard infusible glass, and the end which is not fixed into the cork should be drawn out into a fine open point. As soon as the operator considers that all the common air has been expelled from the bottle, *but not before*, (on account of the violent explosion which occurs when hydrogen, mixed with common air, is inflamed,) apply a light to the gas issuing from the orifice of the tube.—What causes the hydrogen to burn? and what is formed?

54.—Fill a soda-water bottle with equal volumes of chlorine and hydrogen, and inflame the mixture by applying a lighted match to the mouth of the bottle. An explosion will ensue.—What will be formed? and what are its properties?

55.—Describe the oxyhydrogen lime light, and state the part which the lime plays in the illumination.

56.—Introduce a cold body, such as a plate of metal or a piece of glass, or even a piece of card, into a luminous flame; it will speedily become blackened from the deposition of carbon. Intercept the flame, by means of the card, far down, near the wick; then higher up, about the middle of the flame; and then at the top. The deposit of carbon near the wick will be very slight; it will be considerable in the middle of the flame; and only very slight at the top.—Explain the phenomena.

57.—Place a piece of sulphur in a long test tube, or flask of hard glass. Heat the vessel, by means of a lamp, until the sulphur melts, and the vessel has become filled with its vapor. Introduce a narrow strip of tin-foil into the sulphur atmosphere, when the metal will instantly inflame.—What will be formed?

This Expt. may be varied by employing, instead of the tin-foil, a narrow strip of sheet lead; or, very thin iron and copper wires twisted into a coil, and introducing them into an atmosphere of sulphur.—What would be formed in the respective circumstances?

58.—What elements do the following symbols stand for:—Zn—Ni—Na—Ca—Ba—Sb—Hg—Sn?

59.—Give the symbols for the following elements:—Cadmium, Chlorine, Calcium, Carbon, Chromium, Copper, Cobalt, Cæsium.

60.—Of what elements are the following compounds composed:—Ag Cl—Ca F—Pb Br—Hg O—B N—Cu Cl?

61.—Name some of the terms employed in ordinary language to express the combination of substances.

62.—What conditions are necessary for light to be produced in chemical combination?

63.—Name some of the conditions necessary for the combination of phosphorus and oxygen; of phosphorus and chlorine; and the phenomena which accompany the combinations, and the properties of the compounds produced.

64.—State the effects which intense heat has upon solid and gaseous bodies, and give examples.

65.—Do the light and heat emitted by burning bodies bear any proportion to each other? Confirm the opinion expressed by examples.

66.—Why do substances burn more vividly in pure oxygen than they do in atmospheric air?

67.—Upon what facts depends the possibility of artificial illumination?

68.—What is necessary for the production of flame?

69.—Name some of the conditions necessary for the combination of antimony and chlorine; and of sulphur and oxygen; and the phenomena which accompany the combinations, and the properties of the compounds produced.

70.—Of what elements are all materials employed for illumination composed, and what changes do they undergo when burned in the air?

71.—Explain the flame of a candle.

COMBINATION OF A COMPOUND WITH AN ADDITIONAL QUANTITY OF ONE OF ITS ELEMENTS.

72.—Place at the bottom of a long test-tube some crystals of oxalic acid; add to them some strong sulphuric acid, and then warm the tube in the flame of a lamp. As soon as effervescence commences, apply a piece of lighted paper, or a match, to the mouth of the tube, until the evolved gas takes fire; it burns with a blue flame.—What gas is it? and what compound is formed by its burning?

73.—Put into a Woulfe-bottle a few small pieces of metallic copper (copper turnings), and add to the metal, by means of a funnel tube, equal parts of nitric acid and water. Effervescence, without the application of heat, will instantly ensue. On the first evolution of the gas the bottle will be filled with reddish fumes. When they have nearly passed away, the gas may be collected in the usual way, by dipping the exit tube under the mouth of a jar filled with water, and standing inverted on the shelf of a pneumatic trough.—Give the name of this gas, and its composition.

74.—Pass, rapidly, into a jar half full of the gas formed by Expt. 73 (the vessel containing it being inverted on the shelf of the pneumatic cistern), a quantity of oxygen. As soon as the two gases are brought

together, the jar will be instantly filled with an orange-red gas, which is very soluble in water; this liquid will, therefore, rapidly ascend in the vessel by dissolving the new-formed gas. (This experiment furnishes a striking example of the difference between a mere mixture of substances and a chemical compound.)—What is the orange-red gas? Explain the rationale of its formation.

Vary this Expt. by filling a jar with the gas formed by Expt. 73; remove it from the pneumatic cistern, and expose it, with its mouth upward, to the air, when the orange-red fumes will be formed, as in the first case.—Give the rationale.

EVERY COMPOUND SUBSTANCE IS EITHER AN ACID, A BASE, A SALT, OR AN INDIFFERENT BODY.

75.—Fill three wine-glasses, or other convenient vessels, with water. To one, add a few drops of any acid, as hydrochloric; to the second a few drops of any base, as soda or potash; to the third, add nothing, and the water will represent an indifferent body.—Explain the means by which it can be ascertained which glass contains the acid, which the base, and which the neutral or indifferent body.

76.—Add a little water to some caustic (quick) lime. The two substances will combine and form a solid compound.—Name the compound, and state the phenomena attending its formation.

77.—Define the terms, Acid, Alkali, Salt, Base, Neutral, Salt-Radical, Compound, and Mixture.

78.—Pass a stream of carbonic acid gas (prepared in the way described in Expt. 2) through a clear solution of lime (lime-water).—What will take place? Give the rationale.

79.—Can more compounds than one be formed out of the same elements?

80.—Give some proof that atmospheric air is a mixture, and not a chemical compound.

81.—Describe the properties and action of an acid.

82.—What produces the blue flame which is frequently seen on the surface of coal fires?

83.—Give examples to prove that temperature influences combination.

84.—Why will not carbonic acid burn in the air?

85.—Why will not water burn in the air?

SPECIFIC GRAVITY.

86.—What is meant by specific weight?—Describe the "1000 grains bottle," and the principle involved in its use.

87.—If a bottle capable of holding 360 grains of distilled water, holds 320 grains of some other liquid, what is the sp. gr. of that liquid?

88.—If a bottle capable of holding 400 grains of distilled water, holds 470 grains of some other liquid, what is the sp. gr. of that liquid?

89.—If a bottle capable of holding 700 grains of distilled water, holds 600 grains of some other liquid, what is the sp. gr. of that liquid?

90.—Required the weight in pounds of a gallon of linseed oil, its sp. gr. being 0.953.

(NOTE.—An imperial gallon of water weighs 70,000 grains, or 10 lbs.)

91.—Required the weight in pounds of a gallon of turpentine, its sp. gr. being 0.792.

92.—Required the weight of a gallon of the water of the Dead Sea, its sp gr. being 1.172.

93.—Required the weight of a gallon of vinegar, its sp. gr. being 1.063.

94.—Required the weight of a cubic inch of mercury, the sp. gr. of which is 13.59.

(NOTE.—A cubic inch of water weighs 252.458 grains.)

95.—If 100 grains of a solid be introduced into a bottle holding 500 grains of water, and if after the introduction of the solid the bottle weighs 560 grains, what is the sp. gr. of the solid?

96.—If 160 grains of a solid be introduced into a bottle holding 400 grains of water, and if after the introduction the bottle weighs 500 grains, what is the sp. gr. of the solid?

97.—If 300 grains of a solid be introduced into a bottle holding 700 grains of water, and if after the introduction the bottle weighs 850 grains, what is the sp. gr. of the solid?

98.—If 200 grains of a solid be introduced into a bottle holding 400 grains of alcohol, the sp. gr. of which is 0.870, and the bottle weighs, after the solid is introduced, 570 grains, what is the sp. gr. of the solid, taking water as the standard of comparison.

99.—If 300 grains of a solid be introduced into a bottle holding 700 grains of turpentine, the sp. gr. of which is 0.790, and the bottle weighs, after the introduction of the solid, 870 grains, what is the sp. gr. of the solid, taking water as the standard of comparison?

100.—Required the sp. gr. of a solid which weighs 36 grains in air and 26 grains in water.—Explain the law upon which the calculation is based.

101.—A solid, the weight of which in air is 60 grains, weighs 40 grains in water and 30 grains in sulphuric acid; required the sp. gr. of the acid.

102.—A piece of metal, weighing 36 pounds in the air and 32 pounds in water, is attached to a piece of wood the weight of which in air is 30 pounds; the weight of the combined solids in water is 12 pounds. Required the sp. gr. of the wood.

103.—What will be the weight of a block of limestone containing 12 cubic feet; one cubic foot of water weighing 62.5 pounds, and the sp. gr. of the stone being 2.64?

104.—How many cubic feet are there in a block of coal weighing 1 cwt., its sp. gr. being 1.232?

105.—The sp. gr. of bar iron is 7.788; required the weight of a cubic foot.

(NOTE.—The volume of a gallon of water is 277.274 cubic inches.)

106.—The sp. gr. of flint glass is 3.329, required the weight of a cubic foot.

107.—The sp. gr. of oak wood is 0.845; required the weight of a cubic foot.

108.—The sp. gr. of cork is 0.240; required the weight of a cubic foot.

109.—The sp. gr. of ice is 0.930; required the weight of a cubic foot

110.—The sp. gr. of silver is 10.474; required the weight of a cubic inch.

111.—A solid weighs 49 grains in air, and 42 grains in water; required the weight of a cubic foot of the substance.

112.—Into how many classes are the properties of matter divided?

113.—Name the physical properties of oxygen, chlorine, carbon, and mercury.

114.—Name the chemical properties of oxygen, carbon and chlorine.

115.—Enumerate the essential properties of matter, and the non-essential properties of matter.

116.—How many kinds of weight are there? and, what is meant by absolute weight?

117.—What is meant by specific gravity? and, by atomic weight?

118.—Add some nitric acid to copper filings; the copper will disappear, and a beautiful blue solution will be formed.—What is it? Does the acid combine with the metal?

119.—Add some sulphuric acid to iron filings.—What will take place, and what will be formed?

120.—Add some sulphuric acid to some ammonia, in such proportion that the solution, after the addition, has no action upon either blue or red litmus papers.—What does the experiment prove?

121.—Mix some chloride of mercury (corrosive sublimate) with some iodide of potassium. The mixture will be colorless. Then dissolve the mixture in water.—What will take place? and why?

122.—Mix some nitrate of lead with some iodide of potassium. The mixture will be colorless. Then add water to the mixture.—What will take place? Explain the phenomena.

123.—Place a piece of bright metallic iron in a solution of nitrate of copper (a quarter of an ounce of the copper salt to half a pint of water).—What will take place? and what will be formed?

(Name the first of the four great laws of chemical union, and illustrate it by solving the following problems:)

124.—How much water would be produced from 28 lbs. of oxygen and 5 lbs. of hydrogen, and would either of the elements be in excess?

125.—How much hydrochloric acid would be produced from 5 lbs. of hydrogen and 178 lbs. of chlorine, and would either of the elements be in excess?

126.—How much hydriodic acid would be produced from 7 lbs. of hydrogen and 1,000 lbs. of iodine, and would either of the elements be in excess?

127.—How much hydrosulphuric acid would be produced from 6 lbs. of hydrogen and 80 lbs. of sulphur, and would either of the elements be in excess?

128.—How much zinc will combine with 8 parts of oxygen? What compound will be formed, and how many parts?

129.—How much hydrogen will combine with 16 parts of oxygen, and how many parts of water will be formed?

130.—How many parts of potassium will combine with 35.5 of chlorine? What compound will be formed, and how many parts?

131.—How many parts of lead will combine with 48 of oxygen? What compound will be formed, and how many parts?

132.—How many parts of lead will combine with 48 of sulphur. What compound will be formed, and how many parts?

133.—In 9 parts of the compound $H\,O$, what quantity of hydrogen is there, and what quantity of K will replace it?

134.—In 28 parts of the compound $Ca\,O$, what quantity of oxygen is there, and what quantity of sulphur will replace it?

135.—In 20 parts of the compound $Mg\,O$, what quantity of oxygen is there, and what quantity of chlorine will replace it?

136.—Oxygen and potassium unite, in the proportion of 8 of the former elèment to 39 of the latter, to form 47 parts of potassa. What quantity of oxygen is contained in 100 parts of potassa?

137.—Bromine and hydrogen unite, in the proportion of 80 of the former element to 1 of the latter, to form 81 parts of hydrobromic acid. How much bromine is contained in 150 parts of hydrobromic acid?

138.—Every 100 parts of a compound of sulphur and oxygen (sulphurous acid), are composed of 50 parts of sulphur and 50 parts of oxygen. How much oxygen is united with 16 of sulphur, and how many atoms of oxygen is it equal to?

139.—Every 100 parts of a compound of sulphur and oxygen (sulphuric acid), are composed of 40 parts of sulphur and 60 parts of oxygen. How much oxygen is united with 16 of sulphur, and how many atoms of oxygen is it equal to?

140.—Every 100 parts of a compound of phosphorus and oxygen (phosphorous acid), are composed of 56.36 parts of phosphorus and 43.64 parts of oxygen. How much oxygen is united with 31 of phosphorus, and how many atoms of oxygen is it equal to?

141.—Every 100 parts of a compound of phosphorus and oxygen (phosphoric acid), are composed of 43.66 parts of phosphorus and 56.44 parts of oxygen. How much oxygen is united with 31 parts of phosphorus, and how many parts of oxygen is it equal to?

142.—Every 100 parts of calomel are composed of 84.96 parts of mercury and 15.04 parts of chlorine; and every 100 parts of corrosive sublimate are composed of 73.86 parts of mercury and 26.14 parts of chlorine. What quantity of mercury is combined with 35.5 parts of chlorine in the calomel and the corrosive sublimate? and how many atoms of mercury is it equal to in the two compounds?

143.—A compound of manganese and oxygen contains these elements in the following proportions: 27.6 of manganese and 12 of oxygen. Find the atomic proportions.

144.—A compound of manganese and oxygen contains these elements in the following proportions: 27.6 of manganese and 12 of oxygen. Find the atomic proportions.

145.—A compound of manganese and oxygen contains these elements in the following proportions: 27.6 of manganese and 10.66 of oxygen. Find the atomic proportions.

146.—A compound of lead and oxygen contains these elements in the following proportions: 103.7 of lead and 12 of oxygen. Find the atomic proportions.

147.—A compound of lead and oxygen contains these elements in the following proportions: 103.7 of lead and 10.66 of oxygen. Find the atomic proportions.

148.—Write out as complete an answer as you possibly can to the following question: How does chemical affinity differ from the attraction of cohesion?

149.—How many modes are there of forming chemical compounds? Write out a full and complete answer, with examples.

150.—What elements do the following symbols stand for? and how many atoms, and how many parts by weight, do the symbols signify?

Ba—Si—Pt—As—Cu—Mn—Ag—Au—Cd—Co—Ni—B.

151.—What compounds do the following symbols stand for? and how many atoms, and how many parts by weight, do the symbols signify? Name also the constituents of each compound.

Ba O—Sr O—Ca O—Mg O—H O—Co O—Ni O—Zn O—Mn O—Ag O—Cu O—Cd O.

152.—State the number of atoms of each element in one atom of the following compounds, and give the combining proportion of each compound:—

$As\,O_3$—$As\,O_5$—$Pt\,O_2$—$Au\,O_3$—$Al_2\,O_3$—$Mn\,O_2$—$Pb_3\,O_4$.

153.—Explain the meaning of the figures attached to the following symbols: —

$2\,Ca\,O$—$3\,Na\,O$—$2\,C\,O_2$—$5\,As\,O_5$.

154.—Name the following compounds:—

Ca F—Ag I—K Br—Na Cl—Co S—Ni Cl.

155.—Name the following compounds, and if they are named in two ways, give both names:—

Pb S—Ca Cl—Ba P—Ni N—Fe C—Fe Si.

156.—Name the following compounds; and if any of them are named in two ways, give both names:—

H S—H Br—I Cl—S Cl.

157.—Give the names of the following compounds, attaching the proper prefixes:—

$Fe_2\,Cl_3$—$Cu_2\,I$—$C\,S_2$—$I\,Cl_3$—$K\,S_5$—$Ba\,S_4$—$P\,Cl_3$—$P\,Cl_5$—$S_2\,Cl$—$Fe\,S_2$.

158.—Dissolve some iodide of potassium in water (about a drachm of the salt in half a pint of water), and add to the solution a small quantity of chlorine water, obtained by passing chlorine gas through water.—Explain the reactions.

159.—Place in a solution of sulphate of copper (about a quarter of an ounce of the salt in half a pint of water), a piece of bright metallic iron.—Explain the reactions which take place.

160.—Throw a small fragment of potassium into water contained in a dish or plate.—Explain the phenomena; and state the effect which will be produced on blue and red litmus papers by the water.

161.—Introduce a burning taper into a glass jar filled with chlorine gas.—Explain the phenomena which take place.

162.—Moisten a piece of blotting paper with spirits of turpentine ($C_5 H_4$) and introduce it into a jar filled with chlorine gas.—Explain the reactions, and state what compound is formed.

163.—Add some dilute hydrochloric acid (1 part of concentrated acid to 4 of water) to some fragments of zinc.—Explain the reactions, and state what will be formed.

164.—Prepare some sulphide of hydrogen, by adding to some fragments of sulphide of iron, placed in an appropriate apparatus, dilute hydrochloric acid. Collect the gas as it is liberated, in a jar placed over water, in the manner directed for carbonic acid gas in Expt. 2. Subsequently pass a little chlorine gas into the jar.—Explain the phenomena, and state what will be formed.

165.—Prepare some nitrous oxide gas (N O—"laughing gas"). by placing some solid nitrate of ammonia in a retort, and applying heat. The nitrate is decomposed by heat into this gas and water. The gas may be collected in jars at the pneumatic trough. A proper regulation of the heat, so as to avoid a tumultuous disengagement of the gas, is the only precaution required in preparing this gas.

166.—Introduce, by means of the deflagrating spoon, a fragment of lighted phosphorus into a jar filled with nitrous oxide. The gas will be decomposed, not by the mere affinity of the phosphorus for the oxygen—this is insufficient—but by the high temperature of the burning phosphorus and the affinity spoken of.—What will be formed?

167.—Introduce, by means of the spoon, some burning sulphur into a jar of nitrous oxide.—Explain the results, and state what will be formed?

168.—Add to a solution of nitrate of silver a globule of mercury.—State the result, and what the solution now contains. Then dip a slip of clean bright copper into the solution.—What will take place? Then add some nitrate of lead to the solution.—What will be the result? Then place a slip of clean zinc in the solution remaining.—What will take place, and what will the solution now contain?—What do these Expts. teach with regard to the affinity of oxygen for the metals?

169.—Throw a fragment of sodium into a plate of water.—What will take place? and what will be formed?

170.—Repeat the Expt. by using warm instead of cold water.—Explain the difference in the phenomena.

171.—Add dilute sulphuric acid (1 part of $S O_3$ to 4 of water) to a hot concentrated solution of biborate of soda (half an ounce of the salt boiled with 2 ounces of water), until the solution becomes sour to the taste.—What reactions will take place, and what substances will be formed?

172.—Add to a solution of nitrate of lead (4 drachms of the salt to 4 or 5 ounces of water) a solution of caustic soda.—Explain the reactions, and state what will be formed.

173.—Add some lime-water to a hot solution of carbonate of ammonia. —What will take place, and what will be formed?

174.—Add some nitric acid, diluted with twice its volume of water, to some fragments of marble.—What will be formed? Perform this experiment in the apparatus described in Expt. 2, and let the exit tube dip into an open dry glass vessel. The tube should extend to the bottom of the vessel.

175.—Fill two bottles, of equal size, one with carbonic acid gas, the other with hydrogen Fix into the mouth of one of the bottles, after it is filled, a glass tube, two or three inches long, by means of a perforated cork; and, in the same manner, fix the other end of the tube in the other bottle. Place the apparatus on the table, by standing it on the bottom of the bottle containing the carbonic acid, the hydrogen bottle being upward. Let it stand for two or three hours.—What will take place? Explain the principle, and state what will take place on pouring lime-water into the bottles.

176.—Close one end of a wide glass tube, 10 or 12 inches in length, and 1 or 2 inches in width, with a plug of plaster of Paris about half an inch thick. This plug, when dry, is permeated with a multitude of minute pores, which are pervious to gases. This tube (called the diffusion tube), when the plug is dry, is to be filled with hydrogen, by displacement. To accomplish this, a plate of glass is placed first of all upon the exterior of the plug; a tube connected with a gas-holder, or some vessel filled with hydrogen, is then introduced into the diffusion tube until it almost touches the plug. Hydrogen is by this means conveyed from the vessel containing it into the tube, and of course it displaces the air contained in the diffusion tube. When the tube is entirely and solely filled with hydrogen, close the mouth of it with a piece of glass, and then transfer it, with its mouth downward, into a vessel filled with colored water, subsequently removing both plates of glass.—Describe the phenomena which take place under these circumstances.

Vary this Expt. by filling the diffusion tube with atmospheric air, and surrounding it with an atmosphere of hydrogen.—What do these Expts. teach, in relation to gases?

177.—Prepare a solution of carbonate of soda (1 part of the salt to 10 of water), and add to it a solution of sulphate of copper.—What will take place, and what new substances will be formed? Show the reactions by a diagram.

178.—Add a solution of chromate of potash (1 part of the salt to 10 of water) to one of nitrate of lead.—What will be produced? Explain the rationale by means of a diagram.

179.—Project a small piece of phosphide of calcium into a plate of water; this phosphorus compound and water mutually decompose each other.—What is formed? Describe and explain the phenomena attending the Expt.—(*Note:* If the phosphide of calcium has not been recently prepared, employ warm water.)

180.—Add a solution of iodide of potassium to one of nitrate of lead. What will be formed? Illustrate the reactions by a diagram.

181.—Add a solution of iodide of potassium to one of chloride of mercury.—What will be formed? Illustrate the reactions by a diagram.

182.—Fill a tall-stoppered glass jar with binoxide of nitrogen (prepared as directed in Expt. 73); add a few drops of sulphide of carbon, and afterward shake the vessel in such a way as to diffuse the carbon compound in the atmosphere of the jar. When this has been done, remove

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the stopper, and with a lighted taper, which the experimenter must have ready, inflame the gaseous mixture. Its inflammation will be accompanied with a slight explosion.—State the results of the experiment, and illustrate them by a diagram.

183.—Introduce some binoxide of mercury ($Hg\,O$) into a retort of hard glass, and apply a strong heat, by means of a Rose or Berzelius lamp.—What will be formed?

184.—Introduce some red lead ($Pb_3\,O_4$) into a retort of hard glass, and then heat it to redness, by the means directed in the last Expt.—Explain the results, and illustrate them by an equation.

185.—Introduce a quantity of dry and finely powdered nitrate of lead into an earthenware or hard glass retort, which is then to be heated to full redness. The red vapors which will be evolved, are to be conducted into a receiver, carefully cooled by a mixture of snow and salt, where they condense into a liquid.—What decompositions take place, and what compounds are formed? Illustrate by a diagram.

186.—Introduce into a wide tube, or a Florence flask, to which a bent tube is attached, a small quantity of powdered chlorate of potash, and subsequently apply heat.—What reactions take place? Illustrate by an equation.

187.—Introduce into a jar of nitrous oxide (prepared as directed in Expt. 165) a lighted taper, which will burn with increased brilliancy in this gas.—What is the burning of the candle in this gas due to? What decompositions and combinations take place? Explain why the decompositions take place.

188.—Introduce into a jar of binoxide of nitrogen (prepared as directed in Expt. 73) a lighted taper, which will be immediately extinguished.—Explain why it is that the taper will not burn in this gas, while it burns with increased brilliancy in the protoxide of nitrogen.

189.—Introduce, by means of a deflagrating spoon, a piece of dry unignited phosphorus into a jar of binoxide of nitrogen, and then touch it with a red hot wire. The phosphorus will not be ignited.

Remove the spoon from the jar, touch the phosphorus with the hot wire, and it will immediately inflame; then introduce the inflamed phosphorus into the jar of binoxide of nitrogen, and it will continue to burn. —Explain the non-inflammation of the phosphorus in the first Expt., and why it was capable of burning under the conditions of the last Expt. State, also, what new substance is formed.

190.—Mix, in a mortar, very briskly, flowers of sulphur and metallic copper in the state of very fine powder, in the proportion of 16 parts of the former to 32 of the latter. Explain the result.

191.—Put some tartrate of lead into a tube of hard glass; contract the open extremity, but do not completely close it; heat the tartrate gradually, so as to decompose it in succession, beginning at the end nearest the aperture. In this way dissipate all that is volatile. The substance which remains in the tube will inflame the moment it is projected into the air, and will continue to burn for some time.—State what the substance is; why it burns; and what is produced?

192.—Dissolve some phosphorus in bisulphide of carbon, by adding small pieces of phosphorus to that liquid. Draw *rapidly* the outline of some letter or figure with a camel's-hair pencil, or feather, moistened

with this phosphorus solution. In a short time every part of the paper coated with the solution will burst into flame.—Explain the phenomena.

193.—Add a solution of carbonate of ammonia to one of chloride of calcium.—What reactions will take place, and what will be formed? Illustrate by a diagram, and also by an equation.

194.—Add a solution of carbonate of soda to one of nitrate of lead. What will take place, and what will be formed? Illustrate by an equation.

195.—Add to a solution of sulphate of zinc some sulphide of ammonium.—What will take place, and what will be formed? Illustrate by an equation.

196.—Add some dilute sulphuric acid to a few fragments of sulphide of iron, in a bottle.—State the result; and illustrate by a diagram.

197.—Add to an aqueous solution of sulphide of hydrogen, an aqueous solution of sulphurous acid.—What will take place, and what will be formed?

198.—Add sulphuric acid to a solution of chloride of sodium.—State the result, and what will be produced. Illustrate by an equation.

199.—State the properties of platinum sponge; and describe the construction and mode of action of Döbereiner's lamp.

200.—Boil an infusion of litmus, or of red cabbage, with powdered ivory black, and then pass the liquid through filtering paper.—State the results.

201.—Boil an infusion of hops with powdered ivory black, and then pass the liquid through filtering paper.—State the results.

202.—Place a few strips of zinc in concentrated sulphuric acid. In a similar vessel, place a like quantity of zinc, and some dilute sulphuric acid (one part of concentrated acid to 8 of water).—Describe and explain the difference of action in the two cases.

203.—Add concentrated nitric acid to carbonate of baryta; and, in another vessel, some dilute nitric acid to another portion of the same salt.—Describe and explain the results.

204.—Add concentrated sulphuric acid to a few fragments of sulphide of iron; and dilute sulphuric acid to another portion of the iron compound.—Describe and explain the results.

205.—Add absolute alcohol, which is saturated with hydrochloric acid gas, to carbonate of potash. To another portion of the potash salt, add water in which the same gas is dissolved (ordinary liquid hydrochloric acid).—Describe the behavior of the salt in the two cases, and give the reason why.

206.—Chlorine, as has been proved by experiment, combines with phosphorus, with antimony, and some of the other metals, at the ordinary temperature of the atmosphere. Is it probable that at some lower temperature combination will not take place between the chlorine and one or the other of these elements? Give reasons for the opinion expressed.

207.—Is the order of affinity *constant* under all conditions?

208.—What is meant by the *nascent* state?

209.—Name some of the properties of charcoal.

210.—Refer to the list of acids given in the "Table of Acid Sub-

stances," and then say which, if any of the following acids would set free sulphuric acid from the sulphate of potash at a red heat: hydrochloric acid, phosphoric acid, nitric acid, silicic acid, boracic acid.

211.—Enumerate some of the circumstances which affect the order of decomposition.

212.—Name the several circumstances under which decomposition will ensue when acids are added to salts.

213.—Will any change take place when sulphuric acid is added to nitrate of potash, and heat applied?

214.—Name the several circumstances under which decomposition will ensue when bases are added to salts.

215.—Under what condition would it be possible for nitric acid to decompose sulphate of potash?

216.—Ammonia decomposes chloride of lead in solution, and precipitates oxide of lead: is it probable that oxide of lead will decompose chloride of ammonium under some conditions?

217.—Carbonate of lime is insoluble; lime, therefore, removes carbonic acid from potash when carbonate of potash is in solution. What conditions are necessary to render this decomposition complete, and what must be guarded against in order to prevent the potash taking back the carbonic acid from the lime?

218.—Name the several circumstances under which two salts in a state of solution will interchange their acids and bases.

219.—Name the several circumstances under which two salts in the solid state will interchange their acids and bases.

220.—To a solution of sulphate of magnesia add ammonia, which will precipitate a portion of the magnesia as hydrate. To a solution of the same salt, add chloride of ammonium, and then ammonia; in this case the ammonia will not produce a precipitate, as the oxides which are insoluble in ammonia, and yet not precipitated by it in the presence of ammoniacal salts, form with these salts double soluble salts, from which combinations the ammonia can not precipitate them.

221—To a solution of alum add caustic soda, until the precipitate which first forms is redissolved; then add hydrochloric acid until the solution manifests an acid reaction, and finally ammonia in excess.

222.—To a solution of sesquichloride of chromium, add a cold solution of caustic soda, until the precipitate which first appears is redissolved; then boil the solution until the hydrate once more precipitates.

223.—Add caustic soda to a solution of protosulphate of iron. Boil another portion of the solution of the iron salt with a few drops of nitric acid, until it becomes peroxidized, which will be indicated by the solution becoming yellow; when this is attained, add caustic soda in excess. Observe the difference in color between the two precipitates.

224.—Take three portions of a solution of sulphate of copper; to one add ammonia until the precipitate which is first formed redissolves. To the second portion add caustic soda in the cold. Boil the third, and add to it caustic soda.

225.—Mix together a solution of a persalt of iron (obtained as in Expt. 223), and add a solution of sulphate of alumina (common alum can be

employed); add caustic soda to the mixed solution to precipitate the iron; boil and filter. To the filtrate add hydrochloric acid in excess, and, lastly, ammonia, to precipitate the alumina.

Required to know whether any precipitation will occur when the following substances are added together; and if so, what chemical changes must ensue.—The student should state what chemical changes will ensue before the experiment is made; and afterward generalize it. For instance, if he states that sulphate of lead will be precipitated when an aqueous solution of sulphate of copper is added to one nitrate of lead, he must then say whether an aqueous solution of any soluble sulphate, on being added to a solution of nitrate of lead, would produce a precipitate of sulphate of lead; and then he must say whether sulphate of lead would be formed on adding a solution of any soluble sulphate to a solution of any soluble salt of lead. He should generalize every question which admits of it in this way.—See Table of Solubilities, p. 35.

226.—If an aqueous solution of sulphate of copper were added to one of nitrate of lead, what would take place?

227.—If an aqueous solution of sulphate of magnesia were added to one of nitrate of baryta?

228.—If hydrochloric acid were added to an aqueous solution of protonitrate of mercury, the solution of the mercury salt containing a small quantity of free nitric acid?

229.—If an aqueous solution of nitrate of potash were added to one of chloride of calcium?

230.—If an aqueous solution of oxalate of ammonia were added to one of chloride of calcium?

231.—If an aqueous solution of chloride of sodium were added to one of nitrate of lead?

232.—If an aqueous solution of phosphate of soda were added to a hydrochloric acid solution of chloride of calcium?

233.—If sulphide of ammonium were added to an aqueous solution of sulphate of copper?

234.—If an aqueous solution of chromate of potash were added to one of chloride of barium?

235.—If an aqueous solution of sulphate of magnesia were added to one of nitrate of potash?

236.—If an aqueous solution of carbonate of ammonia were added to one of chloride of calcium?

237.—If an aqueous solution of carbonate of soda (any of the carbonates of soda will do) were added to one of protosulphate of iron?

238.—If an aqueous solution of chloride of ammonium were added to one of sulphate of zinc?

239.—If an aqueous solution of chromate of potash were added to a nitric acid solution of nitrate of baryta?

240.—Prepare some sulphide of manganese from the chloride. Explain the process.

241.—Dissolve some soluble salt of baryta in water, and prepare from

that solution the phosphate, chromate, carbonate, and sulphate of baryta. For this purpose, divide the solution into four separate portions; add to one of the four portions a soluble phosphate; to another a soluble chromate; to a third a soluble carbonate; and to the remaining portion a soluble sulphate.

242.—Prepare anhydrous oxide, hydrated oxide, and sulphide of copper, from a salt of that metal which is soluble in water.

243.—Prepare a small quantity of sulphate, carbonate, and chloride of lead, from a salt of that metal which is soluble in water.

244.—Prepare some sulphate of baryta from the carbonate.

(NOTE.—Before soluble salts can be prepared from insoluble ones, the latter must, by acids or other means, be brought into a state of solution.)

245.—Prepare some carbonate of zinc from the sulphide.

246.—Dissolve a salt of baryta and a protosalt of mercury, which can exist together without decomposition, in an appropriate quantity of water. Precipitate the mercury from the solution containing the two salts, by adding to the solution some acid base or salt, which will precipitate it either as insoluble oxide or as an insoluble salt. Filter off from the precipitate thus formed, and to the filtrate (the liquid which passes through the filter), which ought, if sufficient of the substance employed to precipitate the mercury were used, only to contain the baryta (disregarding the substances employed to precipitate the mercury), add some acid base or salt which will precipitate the baryta.

247.—Dissolve a salt of peroxide of mercury and one of lime in water, and separate them in a similar manner.

248.—Dissolve a salt of lime, a salt of zinc, and a salt of peroxide of iron, and separate them in a similar manner.

249.—A manufacturing chemist has a quantity of impure chloride of ammonium, which he desires to purify. The impurity is perchloride of iron. If he were to dissolve the impure ammonia salt in water, could he precipitate the iron in such a way that chloride of ammonium would be the only substance remaining in solution?

250.—Describe Ure's eudiometer, and the method and object of its use. Introduce into it the gases requisite to form water in the proper proportions, and cause them to combine.

251.—Introduce, in the same way, the elements required to form hydrochloric acid, and cause them to combine.

252.—Introduce, in the same way, one volume of oxygen and two of carbonic oxide, and cause them to combine.—What will be produced?

253.—If thin metallic leaves are subjected to the action of an electric current, either from the machine or battery, they inflame and burn with considerable brilliancy.—What is formed in such cases? Is the disappearance of a metal under the action of an electric current, and attended with the evolution of light and heat, proof that it has undergone combustion; that is to say, oxidation?

254.—Describe "Smee's battery," and the apparatus necessary for the electrolysis of water. To which pole does the hydrogen go?

255.—Bend a glass tube, half an inch in diameter and from 8 to 10 inches long, into the shape of the letter V. Fill the tube with a weak solution of sulphate of soda, colored blue with a solution of litmus. In-

sert a plate of platinum foil soldered to a copper wire into the solution at each end of the tube, and connect the opposite end of each wire with the galvanic battery, by means of the binding screws. Describe the phenomena, and state what chemical action takes place.—Then transpose the connections of the wires with the binding screws, and notice and describe the resulting phenomena.

256.—Fill the V tube with a solution of iodide of potassium, containing some starch paste. Insert the platinum plates into the solution, and connect the wires with the battery, as before.—Describe the results.

257.—Introduce into the V tube hydrochloric acid, colored blue with a solution of sulphate of indigo.—What reactions will take place when the current is passed through the acid?

258.—What will take place, if the terminal wires of the battery be dipped into a cup containing fused chloride of lead in solution?

259.—Insert the terminal wires, which must be platinum, into a solution of sulphate of copper.—State the results; and then say what would take place if the portions of the terminal wires inserted in the fluid were copper.

260.—Let three cups, A B C, be placed side by side, and be connected by means of pieces of candle-wick moistened with a solution of sulphate of soda. Let A be filled with a solution of sulphate of soda; B with a solution of dilute sulphuric acid; and C with water. Let the positive wire (platinum) of a battery dip in A, and the negative in C. The positive current will, of course, enter the fluid in A, pass on through the fluid in B and C, and escape by the wire in this latter cup.—State the effects of the current during its passage.

261.—If a vessel be filled with a solution of sulphate of soda, and the wires, terminating in plates, of a battery in action be inserted, the acid will collect upon the one and the alkali upon the other plate; but if, by means of pieces of bladder, the vessel be divided into three compartments, A, B, and C, and the central one being filled with a solution of sulphate of soda, dilute nitric acid is poured into those at the side, in which the plates are placed, in order to afford a conducting medium, no acid or alkali appears at the metallic poles when the current passes. As the compound in B is decomposed, where are its elements evolved?

262.—In what manner can the principle illustrated in the preceding Expts. be demonstrated by the electricity of the machine?

263.—State the nomenclature of Prof. Faraday as applied to a decomposing cell in action.

264.—Mention some of the circumstances which resist the decomposing power of an electrical current; and state the best means of overcoming the resistances you may name.

265.—What are the necessary elements for making a voltaic circuit?

266.—In charging a Leyden jar by means of an ordinary electrical machine, explain fully the whole process which goes on, beginning with the rubber and ending with the jar.

267.—What does the direction of the galvanic current depend upon?

268.—What means are there of obtaining from a voltaic battery electricity approaching in its intensity to that of electricity obtained by friction?

269.—State what is meant by the terms electro-negative and electro-positive.

270.—What is meant by the terms electrolyte and electrolysis?

271.—Give a summary of the more important principles connected with electrolysis.

272.—Mix briskly, in a mortar, about four grains of powdered chlorate of potash, two grains of charcoal powder, and two grains of flowers of sulphur. The substances will react upon one another, the reaction being attended with flame and a slight noise.—State what chemical changes take place.

273.—Mix four grains of powdered chlorate of potash and six grains of flowers of sulphur, very intimately, on paper, by means of a knife or feather; and then divide the powder into three parts. Introduce one part, by means of a knife, into a wine glass containing concentrated sulphuric acid; it will immediately take fire. Place another part in a dry mortar, and then rub very briskly. Slight explosions, accompanied with light, will ensue. Wrap the rest of the mixture in a little tin-foil, lay it on an anvil or a piece of iron, strike it with a hammer, and a loud report will be produced.—State the chemical and physical results.

274.—Mix equal parts of powdered chlorate of potash and powdered loaf-sugar—about 20 grains of each—on paper. Place the mixture upon a plate, and touch it with a glass rod which has just been dipped in strong sulphuric acid; it will immediately burst into a flame.

275.—Powder coarsely a few crystals of nitrate of copper, lay them on a piece of tin-foil, add enough water to make them into a paste, and then quickly fold up the tin-foil, doubling the sides and corners well together, so as to exclude air: in a short time, nitrous acid gas (NO_4) will force its way out of the packet, and the tin-foil will take fire.—Explain the instability of the compounds employed in the last four Expts.

276.—Add a solution of bichromate of potash to a strong nitric or hydrochloric acid solution of peroxide of barium. Violent effervescence and escape of oxygen ensues, owing to the decomposition of the chromic acid and of the peroxide of barium.—What substances result from these decompositions?

277.—Add a solution of permanganate of potash to a strong nitric or hydrochloric acid solution of peroxide of barium, and, as in Expt. 276, a violent effervescence and escape of oxygen occurs.—What are the results?

278.—Add a little oxide of silver to an acetic acid solution of peroxide of barium: oxygen will be again evolved, owing to the oxide of silver being totally decomposed, as well as the peroxide of barium.—What are the results of the decompositions? Illustrate them by an equation.

279.—If chlorine water be poured into vessels containing infusion of blue cabbage, of litmus, or of any vegetable color, what will be the result?

280.—Stain a piece of linen or cotton with port wine or fruit juice; and when dry immerse it in water containing a little free chlorine. The stain will be quickly removed.—What chemical action has taken place?

281.—Take a piece of dyed cotton or linen cloth, and paint upon it some figure, with a paste consisting of ordinary flour paste to which a little tartaric acid has been added. Dry the cloth, and afterward immerse

it in a hot solution of chloride of lime (CaO, Cl.)—Explain the reactions which cause the bleaching.

The student must write out answers to the following questions:—

282.—What substances are termed fermentescible?

283.—What is the difference between putrescible and fermentescible bodies?

284.—State what is meant by the terms Decay, Fermentation and Putrefaction.

285.—Does a *ferment* undergo the same decomposition in the presence of a fermentescible body as it does alone?

286.—Has heat any influence on putrefaction and fermentation?

287.—What is meant by the terms Metameric and Polymeric?

Write out the names of the following compounds in your note-book:—

288.—K Cl.
289.—N H_4 S.
290.—H F.
291.—$F_2 S_3$.
292.—Na I.
293.—Ba F.
294.—Au Br_3.
295.—B F_3.
296.—Zn Br.
297.—Sn Cl_2.
298.—I Cl.
299.—I Cl_3.
300.—Pb I_2.
301.—Mn S.
302.—Pb S.
303.—H S.
304.—H Cl.
305.—H I.
306.—H Br.

Write out the symbols of the following compounds:—

307.—Iodide of potassium.
308.—Bisulphide of ammonium.
309.—Fluoride of calcium.
310.—Sesquibromide of iron.
311.—Terhydride of arsenic.
312.—Iodide of silver.
313.—Chloride of ammonium.
314.—Subchloride of sulphur.
315.—Terbromide of gold.
316.—Quadrosulphide of potassium.
317.—Dinoxide of copper.
318.—Sesquioxide of manganese.

NOTE.—Hydr*ides* and Hydr*ates* are two different classes of compounds. The first are compounds of hydrogen with other substances; the latter are compounds of water with other substances.

The formulæ for the following salts must be written out, along with the combining proportions of acid, base, and salt:—

EXAMPLE.—Sulphate of potash, $KO,SO_3 \left\{ \begin{array}{l} \left.\begin{array}{l} K=39 \\ O=\ 8 \end{array}\right\} 47 \\ \left.\begin{array}{l} S=16 \\ 3O=24 \end{array}\right\} \underline{40} \\ \qquad\qquad\ \ 87 \end{array}\right.$

319.—Sulphate of soda (glauber's-salt).
320.—Sulphate of ammonia.
321.—Sulphate of baryta (heavy spar).
322.—Sulphate of lime (gypsum).
323.—Sulphate of magnesia (Epsom salts).
324.—Sulphate of zinc (white vitriol).
325.—Sulphate of protoxide of iron (green vitriol).
326.—Sulphate of copper (blue vitriol).

327.—Sulphite of potash.
328.—Sulphite of soda.
329.—Sulphite of ammonia.
330.—Sulphite of Lime.

331.—Sulphite of lead.

332.—Subsulphide of mercury.
333.—Sulphide of mercury.
334.—Sulphide of lead (galena).
335.—Sulphide of zinc (blende, black-jack).
336.—Sulphide of barium.
337.—Sulphide of ammonium.

338.—Nitrate of potash (saltpetre).
339.—Nitrate of soda.
340.—Nitrate of ammonia.
341.—Nitrate of lead.
342.—Nitrate of strontia.
343.—Nitrate of silver (lunar caustic).
344.—Nitrate of suboxide of mercury.

345.—Chlorate of potash.
346.—Chlorate of baryta.
347.—Chlorate of soda.
348.—Chlorate of lime.

349.—Chloride of sodium (common salt).
350.—Chloride of ammonium (sal ammoniac).
351.—Protochloride of iron.
352.—Sesquichloride of iron.
353.—Protochloride of tin.
354.—Bichloride of tin.
355.—Subchloride of mercury (calomel).
356.—Chloride of mercury (corrosive sublimate).

357.—Chromate of potash.
358.—Chromate of baryta.
359.—Chromate of lead.

360.—Carbonate of soda.
361.—Carbonate of ammonia.
362.—Carbonate of potash (salt of tartar).
363.—Carbonate of lime (chalk, limestone, marble).
364.—Carbonate of baryta (witherite).
365.—Carbonate of strontia (strontianite).
366.—Carbonate of zinc (calamine, dry-bones).
367.—Carbonate of manganese

368.—Oxalate of potash.
369.—Oxalate of soda.
370.—Oxalate of ammonia.
371.—Oxalate of baryta.
372.—Oxalate of lime.
373.—Oxalate of silver.

374.—Iodide of potassium.
375.—Subiodide of mercury.
376.—Iodide of mercury.
377.—Iodide of lead.

378.—Cyanide of potassium.
379.—Cyanide of silver.
380.—Tercyanide of gold.
381.—Protocyanide of iron.

382.—Cyanide of mercury.
383.—Cyanide of copper.

Write out the names of the following salts:

384.—$Mn\,O, S\,O_3$.
385.—$Hg\,O, Cr\,O_3$.
386.—$Sb\,Cl_3$.
387.—$Zn\,O, S\,O_2$.
388.—$Ag\,O, C\,O_2$.
389.—$Ba\,O, N\,O_5$.
390.—$Sn\,S_2$.
391.—$Pb\,O, \bar{O}$.
392.—$Sr\,O, Cl\,O_5$.
393.—$Hg\,I$.
394.—$Hg\,Cy$.
395.—$Cd\,O, S\,O_3$.
396.—$Fe_2\,Cy_3$.
397.—$Ca\,O, N\,O_5$.
398.—$Ni\,O, S\,O_3$.

Write out the formulæ of the following neutral salts: —

399.—Sulphate of alumina.
400.—Sulphate of binoxide of tin.
401.—Nitrate of the sesquioxide of iron.
402.—Chlorate of the protoxide of mercury.
403.—Silicate of alumina.
404.—Sulphate of the teroxide of antimony.
405.—Sulphate of the sesquioxide of chromium.

Write out the formulæ of the following acid salts; the excess of acid in each example being considered present in the anhydrous state:—

406.—Sesquicarbonate of ammonia.
407.—Quadroborate of soda.
408.—Bisulphate of soda.
409.—Terborate of magnesia.
410.—Sexborate of magnesia.
411.—Sesquisulphate of potash.
412.—Bicarbonate of soda.

Write out the formulæ for the following *basic salts*:—

413.—Dicarbonate of copper.
414.—Triborate of magnesia.
415.—Dicarbonate of lime.
416.—Terbasic subsilicate of magnesia.
417.—Bibasic subsulphate of copper.
418.—Disilicate of lime.

The names of the following compounds must be written out by the student, in order that he may become thoroughly conversant with *all* the rules which have been given:—

419.—$Hg\,O$.
420.—$Cr_2\,Cl_3$.
421.—$Fe\,S$.
422.—$Fe\,O, C\,O_2$.
423.—$Fe_2\,O_3$.
424.—$Au\,Br_3$.
425.—$Zn\,O, S\,O_3 + K\,O, S\,O_3$.
426.—$Ca\,O, Si\,O_3$.
427.—$Ca\,O, 2\,Si\,O_3$.
428.—$2\,Ca\,O, Si\,O_3$.
429.—$Ca\,O, 3\,Si\,O_3$.
430.—$3\,Ca\,O, Si\,O_3$.
431.—$K\,S_3$.
432.—$K\,O, S\,O_2 + H\,O, S\,O_2$.
433.—$Cr_2\,O_3, 3\,S\,O_3$.
434.—$K\,O, 3\,Cr\,O_3$.
435.—$2\,Na\,O, 3\,C\,O_2$.
436.—$2\,Zn\,O, C\,O_2$.
437.—$B.\,F_3$.
438.—$Sn\,O_2, 2\,S\,O_2$.
439.—$Mg\,O, S\,O_3 + K\,O, S\,O_3$.
440.—$Cu_2\,O$.
441.—$2\,Pb\,O, Pb\,Cl$.
442.—$Fe_2\,O_3, 3\,S\,O_3 + N\,H_4\,O, S\,O_3$.
443.—$Na\,O, S_2\,O_2$.
444.—$K\,O, \bar{O} + 3\,(H\,O, \bar{O})$.
445.—$Mn\,O, S\,O_3 + Na\,O, S\,O_3$.
446.—$Cr\,F_3$.
447.—$3\,Pb\,O, N\,O_5$.
448.—$Pt\,I_2, K\,I$.
449.—$Mn_2\,O_3\,3\,S\,O_3$.
450.—$Ba\,O, C\,O_2 + Ca\,O, C\,O_2$.

Write out the formulæ for the following substances:—

451.—Two equivalents of sesquichloride of chromium.

452.—Three equivalents of sulphate of ammonia.

453.—Two equivalents of chloride of platinum and potassium.

454.—Two equivalents of carbonate of lime and magnesia.

455.—One equivalent of phosphate of soda, composed of two equivalents of soda, one equivalent of essential water, and one of anhydrous phosphoric acid.

456.—Two equivalents of silicate of lime.

457.—Three equivalents of felspar, which is a double silicate of alumina and potash.

458.—Three equivalents of the oxalate of the sesquioxide of iron.

459.—Two equivalents of the protoiodide of iron.

460.—Two equivalents of binoxalate of potash.

461.—Three equivalents of phosphate of silver; one equivalent of which is composed of three equivalents of oxide of silver, and one of anhydrous phosphoric acid.

462.—Dolomite (magnesian limestone); composed of one equivalent of neutral carbonate of lime, and three equivalents of neutral carbonate of magnesia.

463.—One equivalent of the sulphate of the sesquioxide of iron and potash (iron alum); which contains, in addition to the sulphuric acid, potash, and sesquioxide of iron, twenty-four atoms of non-essential water.

464.—Two equivalents of sulphate of copper; one equivalent of which is composed of an equivalent of anhydrous sulphuric acid, one of oxide of copper, one of essential water, and six of non-essential water.

465.—One equivalent of the oxalate of the sesquioxide of iron and potash; which contains, in addition to the bases and acid, six equivalents of non-essential water.

466.—One equivalent of oxychloride of antimony (powder of Algarotti); composed of one equivalent of terchloride of antimony, three equivalents of teroxide of antimony, and three equivalents of non-essential water.

467.—Three equivalents of perphosphate of iron; one equivalent of which is composed of two equivalents of sesquioxide of iron, three equivalents of essential water, and three of anhydrous phosphoric acid.

468.—The topaz; composed of one equivalent of alumina, two equivalents of fluoride of aluminum, and six equivalents of a silicate of alumina (one equivalent of which is composed of an equivalent of alumina and one equivalent of silicic acid).

469.—Serpentine; composed of three equivalents of hydrate of magnesia (one equivalent of which contains one equivalent of magnesia and two equivalents of water), and two equivalents of a subsilicate of magnesia (one equivalent of which contains three equivalents of magnesia, and two equivalents of silicic acid).

470.—Meerschaum; composed of one equivalent of sesquisilicate of magnesia, and two equivalents of water.

471.—If hydrosulphuric acid be added to iodine, hydriodic acid will be formed.—What element must be set free?

472.—If hydrochloric acid be added to zinc, hydrogen will be set free.—What compound must be formed?

473.—If sulphuric acid be added to iron, sulphate of protoxide of iron will be formed.—What element must be set free?

474.—If potassium be added to water, potash will be formed.—What element must be set free?

475.—If carbonate of soda be added to nitrate of baryta, what other substances besides carbonate of baryta will be formed?

(Note.—Instead of repeating the propositions and questions in full, we shall, in the following exercises, name the substances brought together under the head of "Substances added," and the substance or substances formed, under the head of "Substances set free or formed.")

Substances added.	*Substances set free or formed.*
476.—Hydrochloric acid. Solution of soda.	Chloride of sodium, And ——?
477.—Solution of carbonate of soda. Solution of nitrate of strontia.	Carbonate of strontia, And ——?
478.—Sulphuric acid. Chloride of sodium.	Sulphate of soda, And ——?
479.—Solution of chloride of sodium. Solution of nitrate of silver.	Chloride of silver, And ——?
480.—Sulphuric acid. Nitrate of potash.	Sulphate of potash, And ——?
481.—Sulphide of ammonium. Solution of sulphate of zinc.	Sulphide of zinc, And ——?
482.—Solution of chromate of potash. Solution of chloride of barium.	Chromate of baryta, And ——?
483.—Solution of hydrate of soda (NaO, HO). Solution of chloride of manganese.	Hydrate of manganese (MnO, HO), And ——?
484.—Solution of carbonate of ammonia. Solution of sulphate of lime.	Carbonate of lime, And ——?
485.—Hydrosulphuric acid. Solution of nitrate of lead.	Sulphide of lead, And ——?
486.—Solution of sulphate of soda. Solution of chloride of barium.	Sulphate of baryta, And ——?
487.—Solution of iodide of potassium. Solution of nitrate of silver.	Iodide of silver, And ——?
488.—Solution of oxalic acid. Solution of nitrate of baryta.	Oxalate of baryta, And ——?
489.—Sulphide of ammonium. Solution of nitrate of cobalt.	Sulphide of cobalt, And ——?
490.—Hydrochloric acid. Solution of nitrate of suboxide of mercury.	Subchloride of mercury, And ——?

Substances added.	*Substances set free or formed.*
491.—Hydrosulphuric acid.	Sulphide of mercury,
Solution of chloride of mercury.	And ——?

(NOTE.—Express the chemical changes which take place in the following exercises, both by diagrams drawn on the blackboard, and by equations.)

Substances added.	*Substances formed or set free.*
492.—Sulphide of ammonium.	Hydrate of sesquioxide of chromium,
Solution of the sesquichloride of chromium.	And ——?

493.—When solid chlorate of potash is ignited, it is decomposed into oxygen and chloride of potassium.—How many equivalents of oxygen will be liberated from one atom of chlorate of potash?

494.—When solid nitrate of ammonia is heated, it is decomposed into nitrous oxide (laughing gas, N O) and some other substance.—What will the other substance be, and how many atoms of each will be formed from one atom of nitrate of ammonia?

Substances added.	*Substances set free or formed.*
495.—Hydrochloric acid.	Sesquichloride of iron,
Sesquioxide of iron.	And ——?
496.—Solution of protochloride of copper.	Subiodide of copper (Cu_2I),
Solution of iodide of potassium.	And ——?
497.—Solution of hydrate of potash ($K\,O, H\,O$).	Oxychloride of copper ($Cu\,Cl, 3\,Cu\,O$ + aq),
Solution of protochloride of copper.	And ——?
498.—Solution of arsenious acid.	Arsenite of copper ($2\,Cu\,O, As\,O_3$),
Solution of sulphate of copper.	And ——?
499.—Protoxide of tin.	Oxysulphide of tin ($5\,Sn\,O_2, Sn\,S_2$),
Sulphurous acid.	And ——?
500.—Solution of hydrate of soda ($Na\,O, H\,O$).	Hydrate of sesquioxide of chromium ($Cr_2O_3, 3\,H\,O$),
Solution of sesquichloride of chromium.	And ——?
501.—Terchloride of antimony.	Oxychloride of antimony ($Sb\,Cl_3, 5\,Sb\,O_3$),
Water.	And ——?
502.—Carbonate of lead.	Dichromate of lead,
Chromate of potash.	And ——?
503.—Terchloride of bismuth.	Oxychloride of bismuth ($Bi\,Cl_3, 2\,Bi\,O_3$),
Water.	And ——?
504.—Solution of the sulphate of the sesquioxide of iron.	Sulphate of the protoxide of iron,
Sulphurous acid.	And ——?

Substances added.	*Substances set free or formed.*
505.—Solution of hydrate of soda. Solution of sulphate of alumina.	Hydrate of alumina ($Al_2 O_3$, 3 H O), And ——?
506.—Solution of phosphate of soda (2 Na O, H O, P O_5). Solution of nitrate of baryta.	Phosphate of baryta (2 Ba O, H O, P O_5), And ——?
507.—Solution of phosphate of soda. Solution of nitrate of silver.	Phosphate of silver (3 Ag O, P O_5), And ——?
508.—Solution of phosphate of soda. Solution of sulphate of copper.	Phosphate of copper (2 Cu O, H O P O_5), And ——?
509.—Solution of phosphate of soda. Solution of chloride of calcium.	Phosphate of lime (3 Ca O, P O_5), And ——?
510.—Solution the sulphate of the sesquioxide of iron. Hydrosulphuric acid.	Sulphate of the protoxide of iron, And ——?
511.—Solution of the phosphate of soda. Solution of ammonia. Solution of sulphate of magnesia.	Phosphate of magnesia and ammonia (2 Mg O, N H_4 O, P O_5), And ——?
512.—Ammonia. Sesquichloride of iron.	Hydrate of the sesquioxide of iron ($Fe_2 O_3$, H O), And ——?
513.—Arsenious acid. Sulphuric acid. Zinc.	Terhydride of arsenic (As A_3), And ——?
514.—Hydrochloric acid. Peroxide of manganese (Mn O_2).	Protochloride of manganese, And ——?
515.—Solution of nitrate of protoxide of copper. Solution of sulphate of protoxide of iron. Solution of iodide of potassium.	Subiodide of copper (Cu_2 I), Sulphate of sesquioxide of iron, And ——?
516.—Solution of carbonate of ammonia. Solution of sulphate of alumina.	Hydrate of alumina ($Al_2 O_3$, 3 H O), And ——?
517.—Sulphide of ammonium. Sesquichloride of chromium.	Hydrate of sesquioxide of chromium ($Cr_2 O_3$, 3 H O), And ——?

	Substances added.	*Substances set free or formed.*
518.—	Solution of carbonate of ammonia.	Hydrate of sesquioxide of iron,
	Solution of sesquichloride of iron.	And ——?
519.—	Solution of phosphate of soda.	Perphosphate of iron ($2\,Fe_2\,O_3$, $3\,H\,O$, $3\,P\,O_5$),
	Solution of sesquichloride of iron.	And ——?
520.—	Solution of carbonate of potash.	Basic carbonate of magnesia $3\,(Mg\,O, C\,O_2 + aq.) + (Mg\,O, H\,O)$,
	Solution of sulphate of magnesia.	And ——?
521.—	Solution of carbonate of soda.	Basic carbonate of zinc ($3\,Zn\,O, H\,O) + 2\,(Zn\,O, C\,O_2$),
	Solution of sulphate of zinc.	And ——?
522.—	Sulphuric acid.	Sulphate of the protoxide of manganese,
	Chloride of sodium.	
	Peroxide of manganese ($Mn\,O_2$).	And ——?

523.—Find the amount of lead in 100 tons of the sulphide.

524.—Find the amount of chlorine, by weight, in 50 lbs. of chloride of sodium.

525.—Find the amount of silver in 1,000 lbs. of sulphide of silver and antimony ($3\,Ag\,S$, $Sb\,S_3$).

526.—Find the amount of platinum in 100 parts of chloride of platinum and ammonium.

527.—Find the amount of iron in 360 grs. of sesquichloride.

528.—What amount of oxygen, by weight, would one ton of sulphur require to be converted into sulphuric acid?

529.—Find the amount of anhydrous nitric acid in 10 lbs. of nitrate of soda, and likewise in the same amount of nitrate of potash.

530.—How much water must 200 lbs. of quicklime absorb to become converted into hydrate?

531.—A chemical manufacturer delivers to his workmen 50 lbs. of metallic silver, to be converted into nitrate (caustic).—What amount by weight of the caustic ought to be obtained?

532.—If 100 grain measures of dilute sulphuric acid neutralize 47 grains of potash, what amount of carbonate of potash, and what amount of ammonia, lime, soda, and their carbonates, will it neutralize?

533.—How much ammonia would 300 tons of coal furnish which contains 1.5 per cent. of nitrogen?

534.—If nitrate of potash and nitrate of soda were the same price per ton, which would be the most economical source for nitric acid? Prove the answer by equivalents.

535.—If it requires 100 gr. measures of dilute sulphuric acid to neutralize 60 grs. of potash, what amount of real sulphuric acid does it contain?

536.—An average crop of turnips removes from an acre of land 54.5 lbs. of phosphoric acid. If the farmer desires to restore his field to its original fertility, what amount of bone earth ($3\,Ca\,O$, $P\,O_5$) would he have to employ to give back the phosphoric acid?

537.—If I borrowed 300 lbs. of nitrate of soda of a nitric acid manufacturer, what amount of nitrate of potash must I return to replace it?

538.—What amount of ammonia would be required to precipitate the sesquioxide of iron from 20 lbs. of sesquichloride?

539.—An average crop of oats removes from an acre of land 198.9 lbs. of inorganic matter; a crop of barley removes from the same extent of land 213.3 lbs. of inorganic matter. In the 198.9 lbs. of mineral matter removed by the oats, there are 23.3 lbs. of phosphoric acid, 36.5 lbs. of potash, and 3.8 lbs. of chloride of potassium:—in the 213.3 lbs. removed by the barley, there are 24.3 lbs. of phosphoric acid, and 38.3 lbs. of potash. If the farmer desired to restore his field to its original fertility, what weight of nitrate of potash, chloride of potassium, or sulphate of potash, and what amount of bone earth (phosphate of lime, $3\,Ca\,O$, $P\,O_5$) would he have to employ in order to give back the potash and phosphoric acid which have been removed by the oats, and what amount would he likewise have to employ in order to restore fertility after the barley crop?

540.—If mercury be added to a solution of nitrate of silver, the silver will be precipitated and replaced by an equivalent of mercury.—The solution will now contain nitrate of mercury, from which the mercury may be precipitated by copper;—the solution will now contain nitrate of copper, from which the copper may be precipitated by lead;—the solution will now contain nitrate of lead, from which the lead may be precipitated by zinc. Suppose we had a solution of nitrate of silver, containing 200 grs. of the nitrate, how much metallic silver would it contain, and how much mercury would it require to precipitate it; how much copper would it require to precipitate this mercury; how much lead to precipitate the copper; and how much zinc to precipitate the lead?

541.—If, in some chemical process, baryta were employed, and an equivalent of strontia, magnesia, or lime could be substituted for it, what would be their relative cost, baryta costing 24 cents per pound, strontia 48 cents, magnesia 12 cents, and lime 2 cents?

542.—How much disulphide of copper would be required to effect the complete reduction of 40 parts of suboxide of copper, 20 parts of protoxide, and 30 parts of green carbonate of copper (malachite, $2\,Cu\,O$, $C\,O_2 + H\,O$), and how much metallic copper would be obtained?

543.—How much galena would be required to reduce a mixture of 20 parts of protoxide of lead, 10 parts of red lead (minium, $Pb_3\,O_4$), and 15 parts of sulphate of lead; and how much metallic lead would be obtained?

Deduce from the following per centage numbers the *relative* number of atoms of the different substances, and give the chemical name of the compound:—

544.—44.44 of C, 51.86 of N, 3.70 of H.

545.—70 of Fe, 30 of O.

546.—44.44 of S, 55.56 of O.

547.—52.14 of Cr, 48.0 of O.

548.—25.96 of $Na\,O$, 66.55 of $S\,O_3$, and 7.49 of $H\,O$.

549.—11.92 of $Na\,O$, 53.46 of $B\,O_3$, and 34.0 of $H\,O$.

550.—34.44 of $Sr\,O$, 35.76 of $N\,O_5$, and 29.8 of $H\,O$.

551.—9.82 of $N\,H_3$, 18.01 of $Na\,O$, 46.19 of $S\,O_3$, and 25.98 of $H\,O$.

552.—18.4 of $K\,O$, 15.6 of $Mg\,O$, 34.4 of $C\,O_2$, and 31.6 of $H\,O$.

553.—54.13 of $K\,O$, 25.23 of $C\,O_2$, and 20.64 of $H\,O$.

554.—68.5 of $Ba\,O$, and 33.0 of $C\,O_2$.

555.—28.81 of $N\,H_3$, 55.93 of $C\,O_2$, and 15.26 of $H\,O$.

556.—8.06 of $N\,H_4$, 44.21 of Pt, and 47.72 of Cl.

557.—23.88 of $Cr_2\,O_3$, 35.82 of $S\,O_3$, and 40.30 of $H\,O$.

558.—55.48 of $Pb\,Cl$, and 44.51 of $Pb\,O$.

559.—9.42 of $K\,O$, 15.56 of $Fe_2\,O_3$, 31.92 of $S\,O_3$, and 43.1 of $H\,O$.

560.—Deduce the rational formula for hyposulphuric acid from the following numbers:—

Sulphur	44.44	Potash	39.554
Oxygen	55.56	Hyposulphuric acid	60.446
Hyposulphuric acid	100.00	Hyposulphate of potash	100.000

561.—Deduce the rational formula of hyperchloric (perchloric) acid from the following numbers:—

Chlorine	38.7	Potash	34.05
Oxygen	61.3	Hyperchloric acid	65.95
Hyperchloric acid	100.0	Hyperchlorate of potash	100.00

562.—Deduce the rational formula for hydrocyanic acid from the following numbers:—

Hydrogen	3.70	Mercury	79.36
Carbon	44.44	Carbon	9.52
Nitrogen	51.86	Nitrogen	11.12
Hydrocyanic acid	100.00	Percyanide of mercury	100.00

563.—Deduce the rational formula for oxalic acid from the following numbers:—

Carbon	26.66	Carbon	8.60
Oxygen	53.33	Oxygen	17.19
Water	20.00	Oxide of lead	74.21
Oxalic acid	99.99	Oxalate of lead	100.00

564.—Find the formula of a salt having the following percentage composition:—

Magnesium	9.76
Sulphur	13.01
Oxygen	26.01
Water	51.22
	100.00

TABLE SHOWING THE SOLUBILITY OF SALTS.—*Fresenius.*

BASES. / ACIDS.	Arsenious.	Arsenic.	Boracic	Carbonic.	Chloric.	Chromic.	Hydrochloric.	Hydriodic.	Hydrosulphuric.	Nitric.	Oxalic.	Phosphoric.	Silicic.	Sulphuric.
Potash	1	1	1	1	1	1	1	1	1	1	1	1	1–2	1
Soda	1	1	1	1	1	1	1	1	1	1	1	1	1–2	1
Ammonia	1	1	1	1	1	1	1	1	1	1	1	1		1
Magnesia	2	2	2	2	1	1	1	1	......	1	2	2	2–3	1
Lime	2	2	2	2	1	1	1	1	1–2	1	2	2	2–3	1–3
Baryta	2	2	2	2	1	2	1	1	1	1	2	2	2–3	3
Strontia	2	2	2	2	1	2	1	1	1	1	2	2	2–3	3
Alumina	2	2	......	......	1	2	1	......	......	1	2	2	2–3	1
Sesquioxide of chromium	......	1	2	2	1	2	1	......	......	1	1	2	2–3	1
Oxide of zinc	......	1–2	2	2	1	......	1	1	2	1	2	2	2–3	1
Oxide of manganese	......	2	2	2	1	1	1	1	2	1	2	2	2–3	1
Protoxide of iron	2	2	2	2	1	......	1	1	2	1	1–2	2	2–3	1
Peroxide of iron	......	2	2	......	1	1	1	1	2	1	1–2	2	2–3	1
Oxide of nickle	2	2	2	2	1	1	1	......	2	1	2	2	2–3	1
Oxide of cobalt	2	2	2	2	1	2	1	......	2	1	2	2	2–3	1
Oxide of antimony	2	2	......	......	......	2	1–2	......	2	......	1–2	......	......	2
Suboxide of mercury	2	2	1	2	1–2	2	3	2	2	1–2	2	2	.....	1–2
Protoxide of mercury	2	2	......	2	1	1–2	1	2	2	1	2	2	......	1
Oxide of lead	2	2	2	2	1	2–3	1–3	2	2	1	2	2	3	3
Oxide of copper	2	2	2	2	1	2	1	2	2	1	2	2	3	1
Oxide of silver	2	2	2	2	1	2	3	3	2	1	2	2	......	1–3
Protoxide of tin	......	2	2	......	......	2	1	2	2	......	2	2	......	1
Peroxide of tin	......	......	......	......	......	.....	1	......	2	1	......	......	......	1
Oxide of bismuth	......	2	2	2	......	2	1	2	2	1–2	2	2	3	1

USE.—If it were required to know whether any precipitation would take place, and if so, what chemical change must ensue, on adding an aqueous solution of carbonate of ammonia and one of chloride of calcium together, we should find by examining the Table that carbonate of lime was insoluble in water; these two salts would, therefore, be mutually decomposed, and two new ones formed, whenever their aqueous solutions were brought together.

To ascertain the solubility of any salt by the Table, find the name of the base in the upright column, and that of the acid in the line at the top: the number placed at the point where the two rows meet shows whether the salt formed by their combination is soluble or otherwise. The figure 1 means that it is soluble in water; 2, that it is insoluble in water, but soluble in hydrochloric or nitric acid; and 3 that it is insoluble in water and acids: 1–2 signifies a substance difficultly soluble in water, but soluble in hydrochloric acid or nitric acid: 1–3, a body difficultly soluble in water, and of which the solubility is not increased by the addition of acids: and 2–3 a substance insoluble in water, and difficultly soluble in hydrochloric acid and in nitric acid.

List of the more important metallic oxides possessing Basic properties.

NAMES.	COLOR.	SYMBOLS.
Potash	White	$K\,O$
Soda	"	$Na\,O$
Ammonia	"	$NH_4\,O$
Baryta	"	$Ba\,O$
Strontia	"	$Sr\,O$
Lime	"	$Ca\,O$
Magnesia	"	$Mg\,O$
Alumina	"	$Al_2\,O_3$
Sesquioxide of Chromium	Green	$Cr_2\,O_3$
Protoxide of Iron	Black	$Fe\,O$
Sesquioxide of Iron	Brownish-red	$Fe_2\,O_3$
Oxide of Zinc	White	$Zn\,O$
Protoxide of Manganese	Greenish-grey	$Mn\,O$
Protoxide of Nickle	Grey	$Ni\,O$
Protoxide of Cobalt	"	$Co\,O$
Oxide of Silver	Brown	$Ag\,O$
Suboxide of Mercury	Black	$Hg_2\,O$
Protoxide of Mercury	Red	$Hg\,O$
Oxide of Lead	Yellow, or reddish-yellow	$Pb\,O$
Oxide of Cadmium	Brown, or yellowish-brown	$Cd\,O$
Oxide of Copper.	Black	$Cu\,O$
Teroxide of Bismuth	Yellow.	$Bi\,O_3$
Protoxide of Tin	Black	$Sn\,O$
Binoxide of Tin	Light straw color	$Sn\,O_2$
Teroxide of Antimony	Greyish-white	$Sb\,O_3$
Teroxide of Gold	Brown	$Au\,O_3$
Binoxide of Platinum	"	$Pt\,O_2$

List of the Principal Acid Substances.

OXYGEN ACIDS.

NAMES.	FORMULÆ.
Sulphurous acid, a gas	$S\,O_2$
Sulphuric acid (Oil of vitriol) a liquid; freezes at 31° Fah.; boils at 640° F.	$H\,O, S\,O_3$
Nitric acid (Aqua-fortis) a liquid; freezes at about —40° F.; boils at 184° F.	$H\,O, N\,O_5$
Chloric acid, an oily fluid; decomposed at 100° F.	$H\,O, Cl\,O_5$
Oxalic acid, a solid; decomposed above 320° F....$HO, C_2\,O_3$=....	$H\,O, \bar{O}$
Phosphoric acid, a solid; volatilizes at very high temperatures...	$3\,H\,O, P\,O_5$
Carbonic acid, (choke-damp) a gas	CO_2

Arsenious acid, a solid; volatilizes at 380° F.	$As\,O_3$
Arsenic acid, a solid; decomposes at a high temperature into $As\,O_3$ and O	$As\,O_5$
Chromic acid, a solid; decomposes, above 400° F., into $Cr_2\,O_3$ and O	$Cr\,O_3$
Boracic acid, a solid; volatilizes very slowly by intense ignition..	$Br\,O_3$
Silicic acid, (Silica, Quartz, Sand) } a non-volatile solid	$Si\,O_3$

HYDROGEN ACIDS.

Names.	Formulæ.
Hydrochloric acid (Muriatic acid, spirit of salts) } a gas	H Cl
Hydrosulphuric acid (Sulphuretted hydrogen) } a gas	H S
Hydrofluoric acid, a very volatile acid, which boils at about 60° F.	H F
Hydriodic acid, a gas	H I
Hydrobromic acid, a gas	H Br
Hydrocyanic acid (Prussic acid) } a very volatile liquid which boils at 80° F. } $H, C_2\,N =$	H Cy

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List of the most important Salts.

OXYGEN SALTS.

Names.	Formulæ.
Sulphites	*$M\,O, S\,O_2$
Sulphates	$M\,O, S\,O_3$
Nitrates	$M\,O, N\,O_5$
Chlorates	$M\,O, Cl\,O_5$
Oxalates	$M\,O, \bar{O}$
Phosphates	$3\,M\,O, P\,O_5$
Carbonates	$M\,O, C\,O_2$
Arsenites	$2\,M\,O, As\,O_3$
Arseniates	$3\,M\,O, As\,O_5$
Chromates	$M\,O, Cr\,O_3$
Borates	$M\,O, B\,O_3$
Silicates	$M\,O, Si\,O_3$

HALOID SALTS.

Names.	Formulæ.
Chlorides (muriates)	M Cl
Sulphides (sulphurets)	M S
Fluorides	M F
Iodides	M I
Bromides	M Br
Cyanides	M Cy

* The letter M stands for any metal.

TABLE A.—*Showing the Solubility of the Basic Oxides and their Hydrates.*

NAMES.	SYMBOLS.	NAMES.	SYMBOLS.
Soluble in Water.			
Hydrate of Potash } *white*	KO, HO	Hydrate of baryta } *white*	BaO, HO
Hydrate of Soda	NaO, HO	Hydrate of strontia	SrO, HO
		Hydrate of lime	CaO, HO
The rest are insoluble in water.			
Soluble in Ammonia and the Fixed Alkalies.			
Hydrate of Zinc (*white*)	ZnO, HO		
Insoluble in Ammonia and the Fixed Alkalies.			
Hydrate of the sesquioxide of iron (*reddish-brown*)	$Fe_2O_3, 3HO$	Suboxide of mercury (forms no hydrate)	Hg_2O
Hydrate of bismuth (*white*)	BiO, HO	Hydrate of the protoxide of mercury (*yellow*)	HgO, HO
Insoluble in Ammonia, soluble in the Fixed Alkalies.			
Hydrate of alumina } *white*	$Al_2O_3, 3HO$	Hydrate of the sesquioxide of chromium (*bluish-green*). (This is insoluble in boiling solutions of the fixed alkalies)	$Cr_2O_3, 3HO$
Hydrate of the protoxide of tin	SnO, HO	Hydrate of lead (*white*). This hydrate is only very slightly soluble in the fixed alkalies.	PbO, HO
Hydrate of the peroxide of tin	SnO_2, HO		
Oxide of antimony	SbO_3		
Soluble in Ammonia; insoluble in Fixed Alkalies. The presence of ammoniacal salts prevents some of them from being completely precipitated by the fixed alkalies.			
Hydrate of cobalt (*pale red*)	CoO, HO	Hydrate of copper (*whitish-green*). (If the fixed alkalies are added to cold solutions of copper salts, the hydrate is precipitated; if added to boiling solutions, the anhydrous oxide is precipitated)	CuO, HO
Hydrate of Nickle (*green*)	NiO, HO		
Oxide of Silver (forms no hydrate)	AgO		
Hydrate of cadmium (*white*)	CdO, HO		

TABLE A.—*Continued.*

Names.	Symbols.	Names.	Symbols.
Insoluble in Ammonia and the Fixed Alkalies, but in the presence of Ammonia salts the volatile alkali cannot precipitate them, and the fixed alkalies only do so in part.			
Hydrate of Magnesia (*white*)	$Mg\,O, H\,O$	Hydrate of protoxide of iron is of a *white* color, which, on exposure to the air, finally becomes red, owing to its being converted into the peroxide.	$Fe\,O, H\,O$
Hydrate of Manganese (*white*), speedily becoming brown by absorbing oxygen from the air, and becoming converted into a higher oxide.	$Mn\,O, H\,O$		

Ammonia does not precipitate the hydrate from solutions of the peroxide of mercury, but a white precipitate having the following composition ($Hg\,N\,H_2 + Hg\,Cl$); the fixed alkalies likewise throw down the same precipitate, if salts of ammonia are present, but in the absence of these salts they precipitate the hydrate.

TABLE B.—*Contrasting the Properties of Bases.*

Oxide of Silver. ($Ag\,O$.)	Sesquioxide of Iron. ($Fe_2\,O_3$.)	Lime. ($Ca\,O$.)
1.—*Hydrochloric acid* precipitates silver from its neutral and acid solutions in the form of chloride ($Ag\,Cl$), because chloride of silver is insoluble in neutral and acid solutions.	1.—*Hydrochloric acid* produces no precipitate in solutions of sesquioxide of iron, because sesquichloride of iron is soluble.	1. — *Hydrochloric acid* does not precipitate lime from its solutions, because chloride of calcium is soluble.
2.—*Ammonia* precipitates oxide of silver from its solutions; but an excess of ammonia re-dissolves it.	2.—*Ammonia* precipitates sesquioxide of iron from its solutions, and it is not re-dissolved by an excess of ammonia.	2.—*Ammonia* does not precipitate lime from its solutions.
3.—*Oxalic acid* produces in neutral, but not in ammoniacal solutions, a precipitate of oxalate of silver, as oxalate of silver is soluble in ammonia.	3.—*Oxalic acid* does not precipitate sesquioxide of iron from its solutions, as oxalate of the sesquioxide of iron is soluble.	3.—*Oxalic acid* precipitates lime as oxalate from its neutral and alkaline solutions.

TABLE C.—*Contrasting the Properties of Bases.*

OXIDE OF COPPER. (CuO.)	ALUMINA. (Al_2O_3)	BARYTA. (BaO.)
1. — *Hydrosulphuric acid* precipitates from its acid solutions as sulphide (CuS).	1. — *Hydrosulphuric acid* does not precipitate alumina from its acid solutions.	1.—*Hydrosulphuric acid* does not precipitate baryta from its solutions.
2.—*Ammonia* precipitates copper from its acid solutions, but an excess of ammonia redissolves the precipitate.	2.—*Ammonia* precipitates alumina from its solutions in the form of hydrate ($Al_2O_3, 3HO$), and an excess of ammonia does not redissolve it.	2.—*Ammonia* does not precipitate baryta from its solutions.
3.—*Sulphuric acid* produces no precipitate in solutions of copper, because sulphate of copper is soluble.	3.—*Sulphuric acid* produces no precipitate in solutions of alumina, because sulphate of alumina is soluble.	3.—*Sulphuric acid* precipitates baryta from its solutions, because sulphate of baryta is insoluble.

TABLE D.—*Contrasting the Properties of Bases.*

OXIDE OF SILVER. (AgO.)	OXIDE OF COPPER. (CuO.)	OXIDE OF ZINC. (ZnO.)
1.—*Hydrochloric acid* precipitates silver from its neutral and acid solutions as chloride.	1.—*Hydrochloric acid* causes no precipitate in solutions of copper.	1. — *Hydrochloric acid* causes no precipitate in solutions of zinc.
2. — *Hydrosulphuric acid* precipitates silver from its acid solutions as sulphide (AgS).	2. — *Hydrosulphuric acid* precipitates copper from its acid solutions as sulphide (CuS).	2. — *Hydrosulphuric acid* does not precipitate zinc from its acid solutions.
3. *Sulphide of ammonium* precipitates silver from its neutral and alkaline solutions as sulphide.	3 *Sulphide of ammonium* precipitates copper from its neutral and alkaline solutions as sulphide.	3.—*Sulphide of ammonium* precipitates zinc from its neutral and alkaline solutions as sulphide (ZnS).

TABLE OF ELEMENTARY SUBSTANCES, WITH THEIR SYMBOLS AND EQUIVALENTS.

Name.	Symbol.	Equivalent.	Name.	Symbol.	Equivalent.
ALUMINUM	Al	13.7	Molybdenum	Mo	48.
ANTIMONY	Sb	120.3	NICKLE	Ni	29.6
ARSENIC	As	75.	Niobium	Nb	48.8
BARIUM	Ba	68.5	*NITROGEN*	N	14.
BISMUTH	Bi	210.3	Osmium	Os	99.6
BORON	B	10.9	*OXYGEN*	O	8.
BROMINE	Br	80.	PALLADIUM	Pd	53.3
Cadmium	Cd	56.	*PHOSPHORUS*	P	31.
Cæsium	Cs	123.4	PLATINUM	Pt	98.7
CALCIUM	Ca	20.	POTASSIUM	K	39.
CARBON	C	6.	RHODIUM	Ro	52.2
Cerium	Ce	47.	Rubidium	Rb	85.36
CHLORINE	Cl	35.5	Ruthenium	Ru	52.2
CHROMIUM	Cr	26.7	*Selenium*	Se	39.5
COBALT	Co	29.5	*SILICON*	Si	21.3
COPPER	Cu	31.7	SILVER	Ag	108.
Didymium	D	48.	SODIUM	Na	23.
FLUORINE	F	19.	STRONTIUM	Sr	43.8
Glucinum	G	7.	*SULPHUR*	S	16.
GOLD	Au	197.	Tantalum	Ta	68.8
HYDROGEN	H	1.	Tellurium	Te	64.2
Indium	In	35.91	Thallium	Tl	204.
IODINE	I	127.	Thorium	Th	59.6
IRIDIUM	Ir	99.	TIN	Sn	59.
IRON	Fe	28.	TITANIUM	Ti	25.
Lanthanum	L	47.	TUNGSTEN	W	92.
LEAD	Pb	103.7	URANIUM	U	60.
Lithium	Li	6.95	Vanadium	V	68.5
MAGNESIUM	Mg	12.	Yttrium	Y	68.
MANGANESE	Mn	27.6	ZINC	Zn	32.6
MERCURY	Hg	100.	Zirconium	Zr	33.6

The twenty-one most important elements are distinguished by being printed in capital letters (as COPPER); those next in importance in small capitals (as ANTIMONY); those which are either of rare occurrence, or of which our knowledge is yet very imperfect, are printed in the smallest type (as Cerium).—The names of the non-metallic elements are printed in *italics* (as *HYDROGEN*, *Selenium*).—Several substances supposed to be elements are not included in this table, as Erbium and Terbium, on account of their rarity and the little that is known about them.

Measures of Length.

	In English inches.	In English feet = 12 inches.	In English yards = 3 feet.	In English fathoms = 6 feet.	In English miles = 1760 yards.
Millimètre	0.03937	0.003281	0.0010936	0.0005468	0.0000006
Centimètre	0.39371	0.032809	0.0109363	0.0054682	0.0000062
Décimètre	3.93708	0.328090	0.1093633	0.0546816	0.0000621
Mètre	39.37079	3.280899	1.0936331	0.5468165	0.0006214
Décamètre	393.70790	32.808992	10.9363310	5.4681655	0.0062138
Hectomètre	3937.07900	328.089920	109.3633100	54.6816550	0.0621382
Kilomètre	39370.79000	3280.899200	1093.6331000	546.8165500	0.6213824
Myriomètre	393707.90000	32808.992000	10936.3310000	5468.1655000	6.2138244

1 inch=2.539954 centimètres. 1 yard=0.9143835 mètre.
1 foot=3.0479449 décimètres. 1 mile=1.6093149 kilomètre.

Measures of Surface.

	In English square feet.	In English square yards = 9 square feet.	In English poles = 272.25 sq. feet.	In English roods = 10890 sq. feet.	In English acres = 43560 sq. feet.
Centiare or sq. mètre	10.764299	1.196033	0.0395383	0.0009885	0.0002471
Are or 100 sq. mètres	1076.429934	119.603326	3.9538290	0.0988457	0.0247114
Hectare or 10,000 sq. mètres	107642.993418	11960.332602	395.3828959	9.8845724	2.4711431

1 square inch=6.4513669 square centimètres.
1 square foot=9.2899683 square décimètres.
1 square yard=0.83609715 square mètre or centiare.
1 acre =0.40467102 hectare.

Measures of Capacity.

	In cubic Inches.	In cubic feet = 1728 cubic inches.	In pints 34.65923 cubic inches.	In gallons = 8 pints = 277.27384 cubic inches.	In bushels = 8 gallons = 2218.19075 cubic inches.
Millilitre or cubic centimètre	0.06103	0.000035	0.00176	0.0002201	0.0000275
Centilitre or 10 cubic centimètres	0.61027	0.000353	0.01761	0.0022010	0.0002751
Dècilitre or 100 cubic centimètres	6.10271	0.003532	0.17608	0.0220097	0.0027512
Litre or cubic décimètre	61.02705	0.035317	1.76077	0.2200967	0.0275121
Décalitre or centistère	610.27052	0.353166	17.60773	2.2009668	0.2751208
Hectolitre or décistère	6102.70515	3.531658	176.07734	22.0096677	2.7512085
Kilolitre, or Stère, or cubic mètre	61027.05152	35.316581	1760.77341	220.0966767	27.5120846
Myriolitre or decastère	610270.51519	353.165807	17607.73414	2200.9667675	275.1208459

1 cubic inch=16.386176 cubic centimètres.
1 cubic foot=28.315312 cubic décimètres or litres.
1 gallon =4.543358 litres.

Measures of Weight.

	In English grains.	In troy ounces=480 grains.	In avoirdupois lbs.=7000 grains.	In cwts.=112 lbs.=784000 gr.	Tons=20 cwts.=15680000 grs.
Milligramme	0.01543	0.000032	0.0000022	0.0000000	0.0000000
Centigramme	0.15432	0.000322	0.0000220	0.0000002	0.0000000
Décigramme	1.54323	0.003215	0.0002205	0.0000020	0.0000001
Gramme	15.43235	0.032151	0.0022046	0.0000197	0.0000010
Décagramme	154.32349	0.321507	0.0220462	0.0001968	0.0000098
Hectogramme	1543.23488	3.215073	0.2204621	0.0019684	0.0000984
Kilogramme	15432.34880	32.150727	2.2046213	0.0196841	0.0009842
Myriogramme	154323.48800	321.507267	22.0462126	0.1968412	0.0098421

1 grain =0.064799 gramme. 1 lb. avoir.=0.453593 kilogr.
1 troy oz.=31.103496 grammes. 1 cwt. =50.802377 kilogrs.

For the ready conversion of gaseous volumes into weights, the *crith*, or standard multiple, proposed by Dr. Hofmann is adopted. The crith is the weight of one litre or cubic decimeter of hydrogen at 0° C. and at a pressure of 760 millimetres of mercury. The following is Dr. Hofmann's description of the value and applications of this unit:

"The actual weight of this cube of hydrogen, at the standard temperature and pressure mentioned, is 0.0896 gramme; a figure which I earnestly beg you to inscribe, as with a sharp graving tool, upon your memory. There is probably no figure in chemical science more important than this one to be borne in mind, and to be kept ever in readiness for use in calculation at a moment's notice. For this litre-weight of hydrogen=0 0896 gramme (I purposely repeat it)—is the standard multiple, or coefficient, by means of which the weight of one litre of any other gas, simple or compound, is computed. Again, therefore, I say, do not let slip this figure—0.0896 gramme. So important, indeed, is this standard weight unit, that some name—the simpler and briefer the better—is needed to denote it. For this purpose, I venture to suggest the term *crith*, derived from the Greek word κριθή, signifying a barley-corn, and figuratively employed to imply a small weight. The weight of 1 litre of hydrogen being called 1 crith, the volume-weight of other gases, referred to hydrogen as a standard, may be expressed in terms of this unit.

"For example, the relative volume-weight of chlorine being 35.5, that of oxygen 16, that of nitrogen 14, the actual weight of 1 litre of each of these elementary gases, at 0° C. and $0^{m}\cdot 76$ pressure, may be called, respectively, 35.5 *criths*, 16 *criths*, and 14 *criths*.

"So, again, with reference to the compound gases; the relative volume-weight of each is equal to half the weight of its product-volume. Hydrochloric acid (H Cl), for example, consists of one vol. of hydrogen + 1 vol. of chlorine = 2 volumes; or, by weight, $1 + 35.5 = 36.5$ units; whence it follows that the relative volume-weight of hydrochloric acid gas is $\frac{36.5}{2} =$ 18.25 units which last figure therefore expresses the number of *criths* which one litre of hydrochloric acid gas weighs at 0° C. temperature and $0^{m}\cdot 76$ pressure; and the crith being (as I trust you already bear in mind) 0.0896 gramme, we have

$$18.25 \times 0.0896 = 1.6352$$

as the actual weight in grammes of hydrochloric acid gas.

"So, once more, as the product-volume of water-gas (H_2O) (taken at the above temperature and pressure) contains 2 vols. of hydrogen + 1 vol. of oxygen, and therefore weighs $2 + 16 = 18$ units, the single volume of water-gas weighs $\frac{18}{2} = 9$ units; or, substituting as before the concrete for the abstract value, 1 litre of water-gas weighs 9 *criths;* that is to say, 9×0.0896 gramme $= 0.8064$ gramme.

"In like manner, the product-volume of sulphuretted hydrogen (H_2S) = 2 litres of hydrogen, weighing 2 criths, + 1 litre of sulphur-gas, weighing 32 criths, together $2 + 32 = 34$ criths, which, divided by 2, gives $\frac{34}{2} = 17$ criths $= 17 \times 0.0896$ gramme $= 1.5232$ gramme = the weight of 1 litre of sulphuretted hydrogen at standard temperature and pressure.

"And so, lastly, of ammonia (NH_3); it contains in 2 litres 3 litres of hydrogen, weighing 3 criths, and 1 litre of nitrogen, weighing 14 criths; its total product-volume weight is therefore $3 + 14 = 17$ criths, and its single volume or litre weight is consequently

$$\tfrac{17}{2} = 8.5 \text{ criths} = 8.5 \times 0.0896 \text{ gramme} = 0.7616 \text{ gramme.}$$

"Thus, by the aid of the hydrogen-litre-weight or *crith* = 0.0896 gramme, employed as a common multiple, the actual or concrete weight of 1 litre of any gas, simple or compound, at standard temperature and pressure, may be deduced from the mere abstract figure expressing its volume-weight relatively to hydrogen."

THERMOMETRICAL EQUIVALENTS.

Rules for converting Degrees of Fahrenheit's, Centigrade, and Reaumur's Thermometers into each other.

The space between the two fixed points of temperature—namely, the freezing and boiling of water, is divided by Fahrenheit into 180°, by Centigrade into 100°, and by Reaumur into 80°:

$\frac{180}{20} = 9.$ $\frac{100}{20} = 5.$ $\frac{80}{20} = 4$: therefore 9 F. represents 5 C. and 4 R.

$$\left.\begin{array}{l} 5 \times 1.8 = 9 \\ 9 \div 1.8 = 5 \end{array}\right\} \text{therefore } \begin{array}{l} \text{C.} \times 1.8 = \text{F.} \\ \text{F.} \div 1.8 = \text{C.} \end{array}$$

The zero of C. and of R. is at the freezing of water: the zero of F. is 32° F. below the zero of C. and of R.

Therefore—1. For temperatures *above* the zero of C. (32° F.)

RULE.	EXAMPLES.
F. − 32 ÷ 1.8 = C. . .	40° F. − 32 (= 8) ÷ 1.8 = 4°.44 C.
C. × 1.8 + 32 = F. . .	4°.44 C. × 1.8 (= 8) + 32 = 40° F.

2. For temperatures *below* the zero of C. (32°), but not below the zero of F. (− 17°.7 C.)

RULE.	EXAMPLES.
F. ∼ 32 ÷ 1.8 = C. . .	20° F. ∼ 32 (= 12) ÷ 1.8 = − 6°.66 C.
− C. × 1.8 ∼ 32 = F. . .	6°.66 C. × 1.8 (= 12) ∼ 32 = 20° F.

3. For temperatures *below* the zero of F. (− 17°.7 C.)

RULE.	EXAMPLES.
− F. + 32 ÷ 1.8 = − C. .	20° F. + 32 (= 52) ÷ 1.8 = − 28°.8 C.
− C. × 1.8 ∼ 32 = − F. .	28°.8 C. × 1.8 (= 52) − 32 = − 20° F

To convert Fahrenheit and Reaumur into each other, use the above rules, only substituting for C. 1.8, R. 2.5. $\frac{180}{80} = 2.5$.

LAW OF GASEOUS VOLUMES.

LAW.—*Equal volumes of all gases and vapors contain, at the same temperature and pressure, an equal number of molecules.*

With very few exceptions, therefore, the molecules of all compounds, no matter how great may be the aggregate volume of their constituents, occupy, when compared at the same temperature and pressure, one uniform volume, which is exactly the same as that filled by one molecule of hydrogen. Thus:

vol. vol.		vols.
1 of Hydrogen + 1 of Chlorine..............	form	2 of Hydrochloric acid.
1 of Hydrogen + 1 of Bromine vapor......	"	2 of Hydrobromic acid.
2 of Hydrogen + 1 of Sulphur vapor......	"	2 of Sulphuretted Hydrogen.
2 of Hydrogen + 1 of Oxygen	"	2 of Steam.
3 of Hydrogen + 1 of Nitrogen	"	2 of Ammonia.
4 of Hydrogen + x of Carbon vapor........	"	2 of Marsh-gas.
6 of Hydrogen + 1 of Oxygen + $2x$ of Carbon vapor..................................	"	2 of Alcohol vapor.
12 of Hydrogen + 1 of Oxygen + $5x$ of Carbon vapor..................................	"	2 of Amylic alcohol vapor.

In order to indicate the difference between the combining measures of the simple and those of the compound gases and vapors, we subjoin a short table of some of the more important.

Gas.	Symbol.	Combining or Atomic Weight.	Combining or Atomic Measure.
Hydrogen	H	1	□ or 1
Oxygen	O	16	□ or 1
Nitrogen	N	14	□ or 1
Chlorine	Cl	35.5	□ or 1
Water	H_2O	18	□□ or 2
Carbonic Acid	CO_2	44	□□ or 2
Nitric Oxide	NO	30	□□ or 2
Ammonia, gaseous	NH_3	17	□□ or 2
Hydrochloric Acid	HCl	36.5	□□ or 2
Ether vapor (a double atom or molecule)	$\left.\begin{matrix}C_2H_5\\C_2H_5\end{matrix}\right\}O$	74	□□ or 2
Alcohol vapor	C_2H_6O	46	□□ or 2
Marsh Gas	CH_4	16	□□ or 2
Olefiant Gas	CH_2	14	□□ or 2
Acetic Acid	$C_2H_4O_2$	60	□□ or 2
Chloroform	$CHCl_3$	48.5	□□ or 2

The chief point to which the student should attend is, that the numbers expressing combining measures count from hydrogen as unity, as is the case with combining weights.

These combining measures have been determined by observing the volumes which the various elements occupy as gases or vapors when taken in their atomic proportions. Thus:

One Atom.			Cubic Inches.
1 grain hydrogen	at 60° F.	and 30 inches bar,	= 46.66
16 grains of oxygen	"	"	= 46.66
35.5 grains of chlorine	"	"	= 46.66
14 grains of nitrogen	"	"	= 46.66

TABLE OF SIMPLE AND COMPOUND GASES AND VAPORS.

Gases and Vapors.	Symbols.	Atom Vol.	Sp. gr. of air 1.	Sp. gr. of hydrogen 1.	Weight of 100 c. i. in grains.
Air	....	...	1.000	14.48	31.00
Hydrogen	H	1	0.0691	1.	2.14
Oxygen	O	½	1.1057	16.	34.24
Nitrogen	N	1	0.9674	14.	29.96
Chlorine	Cl	1	2.4876	36.	77.04
Bromine	Br	1	5.3898	78.	166.92
Fluorine	F	1 ?	....	19.	
Iodine	I	1	8.7066	126.	269.64
Sulphur	S	⅙	6.6336	96.	205.44
Selenium	Se	⅙	16.6390?	240.	515.80
Phosphorus	P	½	4.3555	64.	136.96
Carbon	C	1 ?	0.4146	6.	12.84
Tellurium	Te	⅙	4.4190	38.4	136.98
Arsenic	As	½	10.3900	150.	322.09
Aqueous vapor	HO	1	0.6219	9.	19.26
Protox. of nitrogen	NO	1	1.5202	22.	47.08
Deutox. of nitrogen	NO_2	2	1.0365	15.	32.10
Nitrous acid	NO_4	1	1.5890	46.	49.15
Ammonia	NH_3	2	0.5873	8.5	18.19
Hypochlorous acid	ClO	1	3.0404	44.	94.16
Peroxide of chlorine	ClO_4	2	2.3494	34.	72.76
Hydrochloric acid	HCl	2	1.2783	18.5	39.59
Hydrobromic acid	HBr	2	2.7294	39.5	84.53
Hydriodic acid	HI	2	4.3878	63.5	135.89
Hydrofluoric acid	HF	2 ?	....	10.	
Sulphurous acid	SO_2	1	2.2112	32.	68.48
Hydrosulphuric acid	HS	1	1.1747	17.	36.38
Hydroselenic acid	HSe	1	2.7950	41.	86.64
Phosph. hydrogen	PH_3	2	1.1925	17.5	36.96
Terchlor. of phosph	PCl_3	2	4.7420	70.	147.00
Pentachl. of phosph	PCl_5	4	3.6600	53.	113.46
Carbonic oxide	CO	1	0.9674	14.	29.96
Carbonic acid	CO_2	1	1.5202	22.	47.08
Light carb. hydrogen	CH_2	1	0.5528	8.	17.12
Olefiant gas	C_2H_2	1	0.9674	14.	29.96
Cyanogen	NC_2	1	1.7966	26.	55.64
Hydrocyanic acid	HCy	2	0.9328	13.5	28.89
Tellur. hydrogen	TeH_3	1	4.4881	65.	139.11
Arsen. hydrogen	AsH_3	2	2.7010	39.	83.73
Alcohol	$C_4H_6O_2$	2	1.6100	23.	49.91
Ether	C_4H_5O	1	2.5567	37.	80.25
Chloroform	C_2HCl_3	2	4.1805	60.5	129.59
Oil of turpentine	$C_{20}H_{16}$	2	4.6980	68.	145.63

BAUMÉ'S AND TWADDELL'S HYDROMETERS.

Baumé's *hydrometer* is much used. We subjoin a Table, in which the degrees of this hydrometer are compared with the ordinary range of the specific gravities of liquids.

FOR LIQUIDS HEAVIER THAN WATER.

Degrees.	Sp. grav.	Degrees.	Sp. grav.	Degrees.	Sp. grav.	Degrees.	Sp. grav.
0 ...	1.000	20 ...	1.152	40 ...	1.357	60 ...	1.652
1 ...	1.007	21 ...	1.160	41 ...	1.369	61 ...	1.670
2 ...	1.013	22 ...	1.169	42 ...	1.381	62 ...	1.689
3 ...	1.020	23 ...	1.178	43 ...	1.395	63 ...	1.708
4 ...	1.027	24 ...	1.188	44 ...	1.407	64 ...	1.727
5 ...	1.034	25 ...	1.197	45 ...	1.420	65 ...	1.747
6 ...	1.041	26 ...	1.206	46 ...	1.434	66 ...	1.767
7 ...	1.048	27 ...	1.216	47 ...	1.448	67 ...	1.788
8 ...	1.056	28 ...	1.225	48 ...	1.462	68 ...	1 809
9 ...	1.063	29 ...	1.235	49 ...	1.476	69 ...	1.831
10 ...	1.070	30 ...	1.245	50 ...	1.490	70 ...	1.854
11 ...	1.078	31 ...	1.256	51 ...	1.505	71 ...	1.877
12 ...	1.085	32 ..	1.267	52 ...	1.520	72 ...	1.900
13 ...	1.094	33 ...	1.277	53 ...	1.535	73 ...	1.924
14 ...	1.101	34 ...	1.288	54 ...	1.551	74 ...	1.949
15 ...	1.109	35 ...	1.299	55 ...	1.567	75 ...	1.974
16 ...	1.118	36 ...	1.310	56 ...	1.583	76 ...	2.000
17 ...	1.126	37 ...	1.321	57 ...	1.600		
18 ...	1.134	38 ...	1.333	58 ...	1.617		
19 ...	1.143	39 ...	1.345	59 ...	1.634		

FOR LIQUIDS LIGHTER THAN WATER.

Degrees.	Sp. grav.	Degrees.	Sp. grav.	Degrees.	Sp. grav.	Degrees.	Sp. grav.
10 ...	1.000	23 ...	0.918	36 ...	0.849	49 ...	0.789
11 ...	0.993	24 ...	0.913	37 ...	0.844	50 ...	0 785
12 ...	0.986	25 ...	0.907	38 ...	0.839	51 ...	0.781
13 ...	0.980	26 ...	0.901	39 ...	0.834	52 ...	0.777
14 ...	0.973	27 ...	0.896	40 ...	0.830	53 ...	0.773
15 ...	0.967	28 ...	0.890	41 ...	0.825	54 ...	0.768
16 ...	0.960	29 ...	0.885	42 ...	0.820	55 ...	0.764
17 ...	0.954	30 ...	0.880	43 ...	0.816	56 ...	0.760
18 ...	0.948	31 ...	0.874	44 ...	0.811	57 ...	0.757
19 ...	0.942	32 ...	0.869	45 ...	0.807	58 ...	0.753
20 ...	0.936	33 ...	0.864	46 ...	0.802	59 ...	0.749
21 ...	0.930	34 ...	0.859	47 ...	0.798	60 ...	0.745
22 ...	0.924	35 ...	0.854	48 ...	0.794	61 ...	0.741

Twaddell's *hydrometer* is employed by English Chemical manufacturers. The degrees on Twaddell are readily converted into equivalent specific gravities, by multiplying them by 5, and adding 1000. Thus 8° Twaddell, $8 \times 5 = 40 + 1000 = 1040$. We subjoin a Table of their equivalents:

Degrees.	Sp. grav.	Degrees.	Sp. grav.	Degrees.	Sp. grav.	Degrees.	Sp. grav.
1 ...	1.005	8 ...	1.040	15 ...	1.075	22 ...	1.110
2 ...	1.010	9 ...	1.045	16 ...	1.080	23 ...	1.115
3 ...	1.015	10 ...	1.050	17 ...	1.085	24 ...	1.120
4 ...	1.020	11 ...	1.055	18 ...	1.090	25 ...	1.125
5 ...	1.025	12 ...	1.060	19 ...	1.095	26 ...	1.130
6 ...	1.030	13 ...	1.065	20 ...	1.100	27 ...	1.135
7 ...	1.035	14 ...	1.070	21 ...	1.105	28 ...	1.140

BAROMETRIC SCALE IN MILLIMETERS AND INCHES.

In foreign scientific works, the barometrical pressure, whether for meteorological or other scientific purposes, is represented in millimeters. The subjoined table gives the corresponding equivalents in English inches: the pressure to which gases are submitted, may be thus easily ascertained without resorting to calculation: 762 mm = 30 inches mean pressure.

Mm.		In.	Mm.		In.	Mm.		In.
700	=	27.560	730	=	28.741	760	=	29.922
701	=	27.590	731	=	28.780	761	=	29.961
702	=	27.638	732	=	28.819	*762	=	*30.000
703	=	27.678	733	=	28.859	763	=	30.040
704	=	27.717	734	=	28.898	764	=	30.079
705	=	27.756	735	=	28.938	765	=	30.119
706	=	27.795	736	=	28.977	766	=	30.158
707	=	27.835	737	=	29.016	767	=	30.197
708	=	27.876	738	=	29.056	768	=	30.237
709	=	27.914	739	=	29.095	769	=	30.276
710	=	27.953	740	=	29.134	770	=	30.315
711	=	27.992	741	=	29.174	771	=	30.355
712	=	28.032	742	=	29.213	772	=	30.384
713	=	28.071	743	=	29.252	773	=	30.434
714	=	28.111	744	=	29.292	774	=	30.473
715	=	28.150	745	=	29.331	775	=	30.512
716	=	28.189	746	=	29.371	776	=	30.552
717	=	28.229	747	=	29.410	777	=	30.591
718	=	28.268	748	=	29.449	778	=	30.631
719	=	28.308	749	=	29.489	779	=	30.670
720	=	28.347	750	=	29.528	780	=	30.709
721	=	28.386	751	=	29.567	781	=	30.749
722	=	28.426	752	=	29.607	782	=	30.788
723	=	28.465	753	=	29.646	783	=	30.827
724	=	28.504	754	=	29.685	784	=	30.867
725	=	28.543	755	=	29.725	785	=	30.906
726	=	28.583	756	=	29.764	786	=	30.945
727	=	28.622	757	=	29.804	787	=	30.985
728	=	28.661	758	=	29.843	788	=	31.024
729	=	28.701	759	=	29.882	789	=	31.063

AQUEOUS VAPOR IN GASES.

Temp.		A. V. by vol.	Temp.		A. V. by vol.	Temp.		A. V. by vol.
40°	...	.00933	54°	...	.01533	68°	...	.02406
41	...	.00973	55	...	.01585	69	...	.02483
42	...	.01013	56	...	.01640	70	..	.02566
43	...	.01053	57	...	.01693	71	...	.02653
44	...	.01093	58	...	.01753	72	...	.02740
45	...	.01133	59	...	.01810	73	...	.02830
46	...	.01173	60	...	.01866	74	...	.02923
47	...	.01213	61	...	.01923	75	...	.03020
48	...	.01253	62	...	.01980	76	...	.03120
49	...	.01293	63	...	.02050	77	...	.03220
50	...	.01333	64	...	.02120	78	...	.03323
51	...	.01380	65	...	.02190	79	...	.03423
52	...	.01426	66	...	.02260	80	...	.03533
53	...	.01480	67	...	.02330			